Floriculturist
(Open Cultivation)

(Job Role)

Qualification Pack: Ref. Id. AGR/Q0701
Sector: Agriculture

Textbook for Class XII

विद्यया ऽमृतमश्नुते
एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

ISBN 978-93-5292-331-1

First Edition
July 2020 Ashadha 1942

PD 5T SU

₹ 205.00

Printed on 80 GSM paper with NCERT watermark

Published at the Publication Division by the Secretary, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016 and printed at Shagun Offset Press, F-476, Sector – 63, Noida – 201 301 (U.P.)

OFFICES OF THE PUBLICATION DIVISION, NCERT

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016 **Phone : 011-26562708**

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085 **Phone : 080-26725740**

Navjivan Trust Building
P.O.Navjivan
Ahmedabad 380 014 **Phone : 079-27541446**

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114 **Phone : 033-25530454**

CWC Complex
Maligaon
Guwahati 781 021 **Phone : 0361-2674869**

Publication Team

Head, Publication Division : *Anup Kumar Rajput*

Chief Editor : *Shveta Uppal*

Chief Production Officer : *Arun Chitkara*

Chief Business Manager : *Vipin Dewan*

Production Officer : *A.M. Vinod Kumar*

Cover and Layout

DTP Cell, Publication Division

Foreword

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF – 2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

HRUSHIKESH SENAPATY
Director
National Council of Educational
Research and Training

New Delhi
January 2018

About the Textbook

Agriculture is an important part of India's economy, which accounts for about 18 per cent of the country's GDP and occupies almost 43 per cent of India's geographical area. The agriculture industry employs a large number of people in the organised and the unorganised sector. The requirement of skilled workforce in this sector is increasing day-by-day. The various job roles such as Floriculturist— open cultivation, Floriculturist—protected cultivation, Tuber Crop Cultivator, Micro Irrigation Technician, Solanaceous Crop Cultivator, etc., are being in demand by the States for preparing skilled manpower.

Floriculturist (Open Cultivation) is a person who undertakes various activities of flower cultivation involving preparatory cultivation, and cultivation of flower crops. Their responsibility also involves various production practices and care of plant and various other inputs essential for flower crop cultivation. The job is to be performed in an efficient manner to allow the production of high quality flowers, their harvesting, and post harvest management towards getting higher returns.

The textbook for the job role of Floriculturist (Open Cultivation) has been developed to impart knowledge skills through hands-on learning experience, which forms a part of the experimental learning. Such learning focuses on the learning process for the individual, therefore, the learning activities are student-centred rather than teacher-centred.

The textbook has been developed with contributions of the subject experts, vocational teachers and industry experts and academicians for making it a useful and inspiring teaching-learning resource material for the vocational students. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOS) for the job role so that the students acquire the necessary knowledge and skills as per the performance criteria mentioned in the respective NOS of the Qualification Pack (QP). It has been reviewed by experts to make sure that the content is not only aligned with the NOS, but is also of

high quality. The NOS for the job role of Floriculturist (Open Cultivation) covered through this textbook are as follows:

1. AGR/N0703 Harvest and Post Harvest Management in Floriculture
2. AGR/N9903 Maintain Health and Safety at the workplace

Unit 1 of this textbook introduces cultivation of commercial flower crops—I. Unit 2 focuses on cultivation of commercial flower crops—II. Unit 3 deals with growing of annuals. Unit 4 focuses on the growing of perennials. Unit 5 deals with post harvest management and value addition, while Unit 6 focuses on maintaining health and safety at workplace.

I extend my gratitude to all contributors for sharing their knowledge, expertise and time, and positively responding to our request for development of the textbook.

I hope this textbook will be useful for students and teachers who will opt for this job role. Any further suggestions for improving this textbook are welcome.

Rajiv Kumar Pathak
Professor
Department of Agriculture and Animal Husbandry
PSSCIVE, NCERT, Bhopal

Textbook Development Team

Members

Ajay Kumar Tiwari, *Senior Scientist*, ICAR-Indian Institute of Seed Science, Mau, Uttar Pradesh

Ashutosh Mishra, *Professor* and *Head*, College of Horticulture and Forestry, Jhalawar, Rajasthan

Balaji Shreedhar Kulkarni, *Professor* and *Head*, College of Horticulture, University of Horticultural Sciences, Campus, Bengaluru

Gaurav Sharma, *Assistant Professor*, Department of Floriculture and Landscape Architecture, Indira Gandhi Krishi Vishwavidyalaya, Raipur

Krapal Singh Verma, *Assistant Director,* Horticulture, Sanchi University of Buddhist Indic Studies, Raisen, Madhya Pradesh

Prabhat Kumar, *Senior Scientist*, Division of Floriculture and Landscaping, Indian Agricultural Research Institute (Pusa), New Delhi

R. L. Mishra, Retd. *Project Coordinator*, Floriculture, Indian Agricultural Research Institute (Pusa), New Delhi

Narendra Vasure, *Consultant* (Horticulture), PSSCIVE, Bhopal

Uadal Singh, *Assistant Professor*, Department of Agriculture and Animal Husbandry, PSSCIVE, Bhopal

Vivek Kumar Tripathi, *Associate Professor*, Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur

V.S. Raju Danturluri, *Senior Scientist*, Division of Floriculture and Landscaping, Indian Agricultural Research Institute (Pusa), New Delhi

Y.D. Khan, *Full Time Teacher*, Tulsa Bai Kawal Junior College, Patur, Akola, Maharashtra

Member-coordinator

Rajiv Kumar Pathak, *Professor*, Department of Agriculture and Animal Husbandry, PSSCIVE, Bhopal, Madhya Pradesh

ACKNOWLEDGEMENTS

The Council expresses its gratitude to all members of the Project Approval Board (PAB) and officials of the Ministry of Human Resource Development (MHRD), Government of India, for their cooperation in the development of learning outcome-based curricula and courseware for various job roles in different sectors.

We are also thankful to officials in the National Skill Development Agency (NSDA), National Skill Development Corporation (NSDC), and the Ministry of Skill Development and Entrepreneurship for their support.

The support of Rajesh Khambayat, *Joint Director*, PSSCIVE, Bhopal, is highly appreciated in developing this textbook.

The contributions of faculty members at the Department of Curriculum Studies, NCERT, Saroj Yadav, *Professor* and *Dean* (A), Ranjana Arora, *Professor* and *Head*, Department of Curriculum Studies, and the members of the book review committee are duly acknowledged. Thanks are also due to Sunita Farkya, DESM and Pushp Lata Verma, DESM, for reviewing the textbook thoroughly as a part of the review committee.

The images have been selected with care and diligence for clearer understanding of learners. Care has been taken to not violate any copyright. Creative Commons is acknowledged for Figure 1.12. The images are meant for educational purpose and are being provided for the personal use of students and teachers.

Gratitude is also due to the Publication Division, NCERT, for transforming the manuscript into an attractive textbook. Special thanks are due to Devanshi Tyagi, *Assistant Editor* (Contractual) and Chanchal Chauhan, *Proofreader* (Contractual) for copyediting. The efforts of Pawan Kumar Barriar, *DTP Operator*, Nitin Kumar Gupta and Rajshree Saini, *DTP Operators* (Contractual) Publication Division, NCERT are acknowledged for flawless layout design.

Contents

Do You Know ?

According to the 86th Constitutional Amendment Act, 2002, free and compulsory education for all children in 6-14 year age group is now a Fundamental Right under Article 21-A of the Constitution.

EDUCATION IS NEITHER A PRIVILEGE NOR FAVOUR BUT A BASIC HUMAN RIGHT TO WHICH ALL GIRLS AND WOMEN ARE ENTITLED

Give Girls Their Chance !

Unit 1

Cultivation of Commercial Flower Crops – I

Cultivation of flower crop is an important component of commercial floriculture. There are many flower crops that are grown for cut flowers, loose flowers, *vis-à-vis* for seed production. These crops are used for various purposes. Agro-climatic conditions in a country favour cultivation of a wide range of crops in open field conditions. Now a days, small flower growers are switching to grow crops under protected conditions in their small holdings for earning maximum returns. Quality of flowers grown here is best to meet the international standard, so these flowers are becoming more popular among international community. We have good domestic markets near big cities and up to 70 per cent of the flowers grown in the small holdings are sold there, as there has been a tremendous increase in the income of Indian people, so use of flowers has been a part of their living standard. Thus, only 30 per cent of the grown flowers is left for export. To grow crops for commercial purpose, a cultivator must be aware about the requirements of the crop and

recent techniques developed to obtain better yield with quality product. Knowledge of appropriate agro-climatic conditions is essential to have a quality crop production. Management practices such as selection of improved and suitable varieties according to locality and demand, maintenance of fertility of soil by the application of manures and fertilisers, proper regulation of watering, timely management of weeds, insect-pests and diseases, and proper method of harvesting, grading, sorting and packaging are essential to minimise losses and for obtaining quality products with better yield.

Session 1: Cultivation of China Aster

China Aster *(Callistephus chinensis)*

Family: Asteraceae

China aster, a native of China is one of the most popular annual flowers grown throughout the world. In India, it is grown as traditional flower, though worldwide, it is grown as cut flower, and it is best to be used as bedding and border plant (Fig.1.1).

Fig. 1.1: China aster

Varieties

Kamini, Poornima, Phule Ganesh Pink, Phule Ganesh Purple, Phule Ganesh Violet, Phule Ganesh White, Shashank, and Violet Cushion are Indian bred varieties.

Climate

China aster can be grown year round in areas where night temperature can be maintained around 10–18°C (optimum range being 20–30°C during daytime, and 15–17°C during night) with relative humidity of 50–60 per cent and the site properly exposed to the sun.

Soil

China aster can be grown in a wide range of soils though most suitable ones are well-drained sandy-loam, or loamy soils rich in organic matter and having a pH range of 6.8–7.5.

Propagation

Plants of China asters are commercially propagated through seeds and for one hectare of planting, 2.5–3.0 kg seed is required which is first sown in the nursery and then transplanted. Seeds in the nursery are sown during September–October, and seedlings are transplanted when they attain a height of 10 cm, in about a month.

Land preparation and planting time

To make a fine tilth of soil, field should be ploughed at least thrice to a depth of about 30 cm, followed by planking after every ploughing. Well rotten farmyard manure (FYM) at the rate of 10–15 tonnes per hectare should evenly be mixed in the soil during second ploughing. FYM can be substituted with vermicomposting if available.

In and around the Bengaluru region, the crop can be grown throughout the year, though main seasons are May–June and September–October. In the subtropical regions such as Delhi, its sowing time is September–October, and transplanting is done in October–November, whereas in the temperate regions in the country the seeds in the nursery are sown in September while transplanting is done during October.

NOTES

Spacing

Seedlings of China aster are normally transplanted at a spacing of 30 × 30 or 45 × 45 cm according to soil, growth habit, and season of planting. In light soils, it can be planted at 45 × 20 cm and in medium soil at 60 × 20 cm distance.

Manures and fertilisers

Application of FYM 10–15 tonnes as a basal dose at the time of field preparation and NPK 120:80:120 kg/ha is quite sufficient. Phosphorus and potassium are given only as a basal dose and nitrogen in 2–3 split doses as soil application.

Irrigation

Irrigation requirements depend upon prevailing weather conditions, type of soil, and season of the crop grown. Since it is a winter annual, so in general, irrigation at an interval of 10–12 days is recommended.

Pinching

This is an important practice in some varieties of China aster for getting precocious flowering. Pinching of main shoot at one month after transplanting in variety 'Ostrich Plume Purple' gave a significant increase in the number of nodes, branches, flowers, and flower yield but delayed the flowering by 8–12 days.

Harvesting, yield and postharvest

China aster is harvested in two different ways. Individual flowers are harvested for making garlands and worshipping, while flowers with stalks are harvested for cut flower use. For loose flower use, their harvesting is effected when the flowers are fully open but for cut flowers, these are harvested when the original colour has developed. When flowers are harvested for cut flower, their cut ends are immediately placed in distilled or palatable water, and brought inside the shed for grading and packaging. Life of cut flowers can be extended up to

30 per cent through the use of 60 g sucrose + 250 mg 8-HQS + 70 mg CCC + 50 mg $AgNO_3$ per litre of water in vase solution. About 15–20 t/ha of loose flowers are produced, depending on the varieties used, soil type, cultural operations, and prevailing weather conditions.

Insect-pests

Black blister beetle/aster beetle (*Epicauta pennsylvanica*), a serious pest, feeds on foliage and flowers and mostly destroys the plants completely. Asiatic beetles (*Autoserica castanea*) mostly feed on the leaves during nights and hide themselves in the soil near the base of the plant during daytime. Tarnished plant bugs (*Lygus lineolaris*) are light brown, variously spotted and highly devastating pests as they puncture the terminal shoots below the flower buds which causes the flowers to droop and die. Leafhopper (*Macrosteles fascifrons*) is the most common pest of asters which also acts as virus vector. Leaf miners mine the leaves, remain inside and feed on them. Semilooper caterpillars feed on leaves and flowers and hang themselves through a thread that they emit themselves when alarmed.

Root-knot nematode (*Meloidogyne incognita*) infests China aster roots by galling them, which causes stunting of the plants. Foliage nematode (*Aphelenchoides ritzema-bosi*) feeds on China aster leaves and become very active at 20°C temperature. Nematodes can be controlled by the use of Furadan at 1g/m^2 in the soil, followed by hoeing and watering.

Diseases

Wilt caused by *Fusarium oxysporum f. sp. callistephi* and *Botrytis cinerea* has been found occurring in China aster, showing various symptoms with ultimate wilting of plants. Collar or root rot (*Phytophthora cryptogea*) causes symptoms of water soaking, and blackening of China aster stems and roots with ultimate plant collapse. Stem rot (*Pellicularia filamentosa*) causes rotting of the stem in China aster.

Notes

Gray mould (*Botrytis cinerea*) occurs when weather is cool and humid. Its infection causes burnt appearance on the infected plants in humid weather.

Leaf spot (*Ascochyta asteris, Septoria callistephi* and *Stemphylium callistephi*) occurs on China aster plants. Symptoms of their attack appear as yellowing of leaves, starting from the lower leaves, turning them brown and then black, which through coalescing become larger in size.

All these are controlled through spraying of 0.2% zineb or maneb twice in a week. Canker (*Phomopsis callistephi*) causes China aster canker on the lower part of the stem, completely damaging the distal portion though the root is untouched. Rust (*Coleosporium solidaginis*) is a serious problem in China aster causing bright yellowish-orange spots on lower surface of leaves, especially in young plants, and this is controlled through use of wettable sulphur. All these pathogens can be controlled by spraying the infected plants with 0.2% captan, mancozeb, zineb, or carbendazim, or through 0.1% spraying of calixin.

Virus

Chrysanthemum mosaic virus (that is a seed-borne disease), California strain of aster yellows, spotted wilt, and curly top are the major viruses infecting China aster. Controlling of insect vectors will check the spread of various viruses. Infected plants should be uprooted and burnt.

Practical Exercise

Activity 1

Demonstrate the harvesting of China aster as a cut flower.

Material required

Scissor or secateur, a bucket with water. China aster flowers are harvested as loose (without stalk, for making garlands, and worshipping purposes), and with stalks as cut flower use.

Procedure

- Select long stalked fully colour developed flowers.
- With the help of scissor or secateur, cut the stalk of the flower as long as possible.

- After cutting, immediately place their cut ends in distilled or palatable water.
- Then bring the flowers inside the shed for grading and packaging.
- The life of the cut flowers can be extended by the use of holding solution.

Check Your Progress

A. Fill in the Blanks

1. For China aster cultivation, _____ soil is best with a pH range of _____.
2. In China aster application of FYM, _____ tonnes and _____ NPK kg/ha are found beneficial.
3. Individual flowers are harvested for making _____ and _____.
4. China aster is commonly propagated by _____.
5. For commercial cultivation of China aster, the seed rate requirement is _____ kg/ha.

B. Multiple Choice Questions

1. Optimum temperature range required for China aster during the day and night is —
   (a) 20–30°C and 15–17°C
   (b) 30–35°C and 17–19°C
   (c) 25–35°C and 13–15°C
   (d) 35–40°C and 19–21°C
2. China aster can be planted at _____ cm spacing.
   (a) 20 × 20 or 35 × 35
   (b) 25 × 25 or 40 × 40
   (c) 35 × 35 or 50 × 50
   (d) 30 × 30 or 45 × 45
3. Normal growing season of China aster is _____.
   (a) June–July and October–November
   (b) February–March and July–August
   (c) May–June and September–October
   (d) November–December and April–May
4. Yields of China aster is about _____ tonnes/ha loose flowers.
   (a) 14–16
   (b) 18–20
   (c) 20-22
   (d) 22–25
5. A serious insect pest of China aster is —
   (a) Aster beetle (Epicauta pennsylvanica)
   (b) Leafhopper (Macrosteles fascifrons)
   (c) Tarnished plant bugs (Lygus lineolaris)
   (d) Root aphid (Anuraphis maidi-radicis)

NOTES

C. Subjective Questions

1. Define pinching in aster.

_____

_____

_____

2. Name any five varieties of China aster.

_____

_____

_____

3. Describe propagation of China aster.

_____

_____

_____

4. Write about planting and transplanting of China aster.

_____

_____

_____

D. Match the Columns

A	B
1. Stunting of the plants	(a) Pellicularia filamentosa
2. Gray mould	(b) Very active at 20°C temperature
3. Stem rot	(c) Nematodes control
4. Foliage nematode	(d) Root-knot nematode
5. Furadan at 1g/m^2	(e) Botrytis cinerea

Fig. 1.2: Chrysanthemum

Session 2: Cultivation of Chrysanthemum

Chrysanthemum (*Dendranthema grandiflora*, formerly called *Chrysanthemum morifolium*)

Family: Asteraceae

Chrysanthemum (Queen of East/Autumn Queen, *Guldaudi*), widely grown worldwide is the oldest flowering plant. It is used as

potted plant (pot mums), as well as, cut flower, and in Asia, even as loose flower.

Types and varieties

Broadly, these are classified into seven groups:

Single

These have up to five radiating whorls with strap-like ray florets and conspicuous disc.

Fig. 1.3: Single

Anemone

These are well-developed disc florets. So the disc is raised and the ray florets are either tubular or ligulate.

Fig. 1.4: Anemone

Fig. 1.5: Pompon

Pompon

This type has invisible disc, small, but quite compact with hemispherical shape, where ray florets are short, broad, and regularly arranged.

Decorative

This type has an invisible disc due to ray florets being present over the entire capitulum; and is large or pompon-type small-flowered.

Fig. 1.6: Decorative

Fig. 1.7: Incurved

Fig. 1.8: Reflexed

Fig. 1.9: Intermediate

Incurved

Flowerhead is fully double, and perfectly globular where petals are incurving and closed tightly over the crown.

Reflexed

Flowerheads are rounded and fully double with petals falling (curving) outwards and downwards touching the stem, often with curl or sideways twist and overlapping as bird's feathers. These maybe fully reflexed, partly reflexed, or reflexed having spiky outline.

Intermediate (formerly incurving)

Here, flowerheads are double and globular, but halfway between the incurved and reflexed. Where petals are loosely incurving with regular shape, it is named as *formal intermediate*, and where these are irregularly incurving, it is known as *informal intermediate*.

Chrysanthemum varieties can be classified as:

Standard varieties (large flowered varieties)

Basanti, Bronze Princess Anne, Gay Anne, Giant Indianapolis White, Indira, Jaya, Mahatma Gandhi, Pink Champagne, Purnima, Purple Anne, Rakhi, Red Gold, Red Resilient, Shanti, Sharad Mala, Snowball, Sonar Bangla, Tata Century, Thai Chung Queen, Vaatika, White Star, Yellow Fred Shoesmith, Yellow Star, etc.

Spray varieties (small flowered varieties)

Ajay, Apsara, Arctic, Baggi, Birbal Sahni, Cameo, Charlia, Flirt, Jayanti, Jubilee, Kundan, Lal Pari, Nanako, Pusa Anmol, Pusa Aditya, Riot, Surf, White Bouquets, etc.

Climate

Chrysanthemums are short day plants, as for profuse flowering these require short days though for better vegetative growth, these require long days. The critical

day length is 14–15 hours for vegetative growth and less than 12 hours for flower initiation. For optimum flowering, it requires 20–28°C temperature in the day time and 5–20°C temperature in the night time.

Soil

Chrysanthemum can be grown on various types of soils; however, sandy-loam to loamy soils rich in organic matters are more suitable having around pH of 6.5, but the soil should not be waterlogged.

Propagation

Commercially, chrysanthemum is propagated through suckers and terminal cuttings, but it is done even through seeds for evolution of new varieties though many of the improved varieties do not set seeds except the certain small-flowered spray and pompon types. Only a few types among the large-flowered ones set seeds.

Seeds

Plants raised through seeds exhibit a large range of variations including colour, shape, and size. These germinate within 10 days and become ready for transplanting in about 40 days.

Suckers

When flowering is over, the stem of chrysanthemum is cut off just above the ground to induce suckering. After sufficient growth, the suckers are separated and planted in sandy soil, and those having well-formed roots are directly transplanted in the field. Suckering is a natural phenomenon which is further encouraged by removal of main shoot after flowering, and as these suckers already have roots so their establishment is almost certain with early take off, although there is no uniformity in growth and flowering, and there are greater chances for carrying diseases the mother plant had.

Cuttings

Terminal or tip cuttings, 5–8 cm long, are taken from a healthy stalk. Cuttings dipped in Seradix or 500 ppm IBA are inserted 3–5 cm apart, in sand beds, made under filtered light, followed with irrigation immediately

and daily until 3–4 weeks when these become ready for transplanting. Though these start slowly with a high mortality rate as compared to suckers but by and large remain healthy and come up uniformly.

Land preparation

For chrysanthemum growing, there should be three deep ploughings, each followed by planking, where at second ploughing some 300–500 quintals/ha well rotten compost or farmyard manure should evenly be mixed, and after the third ploughing, the soil should make a fine tilth. All the foreign materials including the rootstocks of perennial weeds, stones, grits, chips, wood pieces, polythene shreds, etc., are to be taken out, soil is to be properly levelled, and then beds of convenient sizes are to be made by having provision of bunds and irrigation channels.

Planting

Cuttings are planted immediately after these have been rooted. Ideal planting time is May–June. In North India, planting should be carried out after the second week of June. It would be better to plant first in the nursery beds, and then finally transplanting in the permanent beds after one month, followed by immediate irrigation. It should be ensured that wherever the chrysanthemums are to be transplanted, the soil should be free of waterlogging so it would be better to transplant the rooted cuttings on ridges.

Planting density influences plant vigour and flower quality. Density may differ due to agroclimatic conditions prevailing at a location, and from variety to variety. In case of cut flower varieties, the plant density may go up to 64/m^2; however, for economic returns the plant density may be maintained at 25–32/m^2. Usual spacing being kept in India is 20 × 30 cm, 30 × 30 cm, or 40 × 40 cm/m^2, however, the spacing of 20 × 30 cm gives best economic yield.

Irrigation

Watering the plants solely depends on the stage of plant growth, the soil type, soil moisture level, prevailing weather condition, and relative atmospheric humidity.

Immediately after transplanting, the chrysanthemums are at once watered to recover from the lifting shock and for proper settling of roots, and thereafter, these are watered at an interval of every four days in the summer season, however in winters, these maybe watered at an interval of 7–10 days. Until these are properly established, the soil should remain continuously moist, but thereafter the scarcity should alternate with the sufficiency of water so that the growth of plants is proper. Proper drainage system must be maintained throughout the crop duration.

Manure and fertilisers

If sufficient quantity of farmyard manure has been incorporated in the soil at the time of bed preparation, it does not require any further feeding except the specific ones. In case sufficient FYM is not available, and as this is heavy feeder for nitrogen and potassium, so 50:160:80 kg NPK/ha fertiliser may be applied afterwards for good results. Phosphorus, a slow-release fertiliser, is applied as the basal dose before planting along with some 20 kg of nitrogen. The other two split doses of nitrogen should be applied after every two months of planting but not at the stage when the buds are likely to be formed. It would be better if the first nitrogen application matches with first pinching. Entire potassium fertiliser should also be applied as basal dose.

Staking

Stakes in chrysanthemum are very necessary to keep the plants straight, in proper shape, and to support the plants from lodging when in bloom, especially in case of taller varieties. Normally used stakes are prepared from willows and bamboos. For a single bloom production, only one stake is required but for heavy bloomers, three to five stakes are used to control outside growth of the plants in pots. The stakes should always be slightly smaller than the level of blooms for a perfect and spectacular viewing.

De-suckering

Removeal of suckers is necessary so that energy is saved for the growth of main shoot, otherwise flower quality will be hampered drastically.

NOTES

Pinching or stopping

Pinching in chrysanthemum is carried out usually by hand. It refers to the removal of growing tips at the 10–15 cm stage, so that many lateral shoots are formed for precocious flowering. In certain varieties, the practice is repeated after 30–45 days of first pinching for multifold increase of floral buds so that at the flowering stage, the plant is full of blooms.

Disbudding and de-shooting

These operations are carried out mostly in the large-flowered and decorative varieties. Disbudding is the removal of side buds to control the number and size of flowers. In large flower type cultivars, immature flower buds are removed to get large size flowers or a large number in small flower type cultivars. In standard types and others where only one largest bud is desired, other axillary buds around the centre are removed. In spray varieties, the large central bud is removed and the lateral ones are allowed to develop depending upon the type of spray to be produced.

Weed control

For maintaining uniform warmth in the soil, to conserve moisture, and to hinder the emergence of weeds in the crop, 5–7 cm thick mulches made of sawdust, straw, etc., are spread on the ground. In small holdings, the weeding should be carried out manually, while in the large scale plantings, herbicides such as trifluralin at 4 kg/ha as pre-emergence should be applied.

Use of growth regulators

Ascorbic acid spraying at 1000 ppm (1 g/l) after 30 or 70 days of transplanting increases the overall growth of plants. Spraying of B-nine at 5000 ppm provides highest number of flowers per plant. GA_3 at 500 ppm should be sprayed at 30, 45, and 60 days after planting for increasing flower yield manifold. Number of quality flowers is increased when plants are sprayed with 0.1% tricontanol.

Harvesting

Standard chrysanthemum is harvested when fully open, but before central disc starts elongating. Spray cultivars are harvested when fully open but before the shedding of pollen, and pompons are harvested when the centre of oldest flower is fully open. Harvesting should be done early in the morning. The average yield of good quality flower ranges from 10–15 tonnes/ha.

Insect-pests

Aphids

Small greenish to black-dotted tiny insects, where nymphs and adults both cluster on the tender plant parts (flower buds, young leaves, and branch tips). Apart from sucking the sap, they also excrete honeydew which attracts ants and sooty mould, *vis-à-vis* act as a carrier of various viruses.

Thrips

Nymphs and adults of the thrips are also tiny insects which damage the plants similar to aphids but these don't secrete honeydew or attract ants or act as a virus vector.

Leafminers

Larvae mine the leaves and keep on feeding the tissues under the epidermis so the leaves are disfigured with irregular white linings.

These insects can be controlled effectively through spraying the plants with dimethoate (0.3%), thiodan 1.25 ml/l or dicofol (0.05%). Use of predatory midge (*Aphidoletes aphidimyza*) and lacewigs (*Chrysopa sp.*) as well as fungi *Beauveria bassiana* and *Verticillium lecanii* can effectively be used for control of aphids. Predatory insects such as *Neoseiulus cucumeris* and *N. barkeri* are used against thrips, *Orius insidiosus* and *O. tristicolor* against Western flower thrips as well as onion thrips, and the entomopathogenic fungus have been found effective against thrips. For controlling leaf miners, *Diglyphus begini* and *Dacnusa* wasps have been found quite effective.

NOTES

Whiteflies

These are havoc in a chrysanthemum field, especially in the greenhouses. Their attack causes leaf yellowing-cum-drying, and in severe infestation, the plants are even killed. These also transmit the viruses. In abundance, these start flying over the crop when the plants are slightly shaken.

There is no effective chemical control for this pest but placing of at least one yellow sticky trap/10 m^2 is quite effective. Parasitic wasp such as *Encarsia formosa*, predatory coccinellid beetle (*Delphastus pusillus*) and entomopathogenic fungus (*Paecilomyces fumosoroseus*) are effective for controlling whiteflies.

Mealybugs

Nymphs and adults are utterly slow-moving insects having shining white to gray covering on their entire bodies. They are found clustered especially on the shoot tips sucking plant sap. Their severe attack causes the plants to be infected by various pathogens, so the plants are likely to die. For pest control, preventive spray of NSKE or azadirachtin 0.5 ml/l is the first step, pesticides such as acephate, azadirachtin, bendiocarb, chlorpyriphos or diazinon control mealybugs effectively when sprayed fortnightly 3–4 times. Parasitic insects such as *Lindorus lophanthae* and *Metaphycus helvolus* parasitoid the mealybugs, but their availability for field application is generally different. Ladybird beetle is often a good parasite for mealybugs.

Bihar or Hairy caterpillar

The chrysanthemum plants are attacked during rainy season and attack continues until winter by the greenish-brown caterpillar having dark markings. These can be hand-picked and killed. White grubs also feed on the underground parts of the plants during hot weather.

Monocrotophos at 1 ml/l or carbaryl at 2 g/l is effective in killing the caterpillars. Against white grubs, the pathogenic nematode *Steinernema carpocapsae* should be introduced in moist soil through water at 14–20°C temperature. These enter the body of the grub and release bacteria that cause a fatal infection.

Red spider mites

These are quite tiny dot-like red insects which can be found sticking to the underside of leaves, and sometimes even on open flower buds of the plant sucking their sap, especially during summer.

Two to three weekly sprayings with methyl demeton at 1 ml/l or dicofol at 2 g/l is effective in controlling these mites. Parasitic mites such as *Neoseiulus californicus, Mesoseiulus longipes, Phytoseiulus persimilis,* etc., are effective in controlling these mites.

Root-knot nematodes

Nematodes feed the chrysanthemum roots by making galls and their infestation causes cupping of leaves, *vis-à-vis* plant distortion and stunting. Root knots can be observed by uprooting such plants.

The soil should be sterilised before planting. Oxamyl 10G either as a soil drench, as granules, or as sprays will control the nematodes.

Diseases

Root rot and damping off *(Pythium sp., Phytophthora sp.)*

These are serious soil-borne diseases during warm and moist conditions due to which the rotting of stem cutting occurs. These fungi also enter the plants through the wounds inflicted through pinching. Its infection causes sudden wilting of roots, thereby causing drooping of leaves and stems. Infected cuttings should be destroyed and soil should be drenched with orthocide or etridiazole + thiophanate-M or metalaxyl.

Sclerotinia rot *(Sclerotinia sclerotiorum)*

It is symptomised as light brown lesions on the stems. This develops rapidly girdling the stem by which the plants ultimately wilt. During wet weather, a dense white fluffy fungal growth appears. Before planting, the soil should be sterilised with chloropicrin/formaldehyde/ methyl bromide and on the plants 1.5 g/l carbendazim or 2 g/l benomyl should be sprayed.

Verticillium and Fusarium wilts *(Verticillium albo-atrum, Fusarium oxysporum var. tracheiphilum)*

These are highly devastating diseases to chrysanthemums. These fungi being soil-borne enter the plants through roots. At initial infection, conspicuous leaf yellowing and browning appears but later on progress upwards so the plants become weak and stunted and mostly fail to produce flowers. This is most prevalent in glasshouse grown chrysanthemums. Soil drenching with dexon or carbendazim is effective against these diseases.

Rayblight *(Didymella chrysanthemi, Mycosphaerella ligulicola)*

It is symptomised by flowers becoming one-sided due to deformed ray florets at one side. Their early infection causes even bud blasting. Due to rotting, the inner florets become dark brown. To control these maladies the field humidity should be proper, infected plants should be removed and sprayed with benomyl and mancozeb at 2 g/l, and resistant varieties such as 'Iceberg', 'Irene', 'Minong', and 'Red Daisy' should be used.

Leaf spots *(Septoria chrysanthemi)*

These initially appear late in the season on older leaves as grey-brown circular spots which afterwards turn dark brown to black covering the entire plant. There are certain other pathogens also causing leaf spots, and in such cases, dark brown spots with yellowish margins are produced which expand in size afterwards covering the entire leaf. Leaf spots can be prevented by fortnightly spraying of bordeaux mixture or mancozeb at 0.2% along with sticker (0.1%).

White rusts *(Puccinia horiana, P. chrysanthemi)*

This is the most common problem in chrysanthemum. Symptoms appear as small blisters on the undersurface of leaves, which on eruption release light brown spores. At early stages, the infected leaves should be collected and destroyed; leaves at no time, should remain wet so overhead watering should be avoided, and zineb, or captan (0.15%) should be sprayed for effective control.

Bacterial leafspot (Pseudomonas cichorii)

It appears as dark brown to black sunken spots with concentric areas. To prevent this problem, streptomycin or cupric hydroxide or copper pentahydrate can be used to treat the infected plants.

Viral and phytoplasma diseases

Tomato spotted wilt virus (TSWV), turnip mosaic virus (TuMV), tomato aspermy virus (TAV), chrysanthemum virus B (CVB) and aster yellows have been found attacking chrysanthemums. TSWV produces ring and line patterns, paled areas, mottling and necrotic spots on the leaves so cuttings taken from such plants become the source of further infection. TuMV causes mottling in the infected plants. TAV is transmitted by *Acyrthosiphon solani, Macrosiphoniella, Myzus persicae,* etc., aphids and causes distortion and irregular flower colouration. CVB has also been recorded on chrysanthemum plants. Aster yellows mycoplasma infection causes greening of flowers, precocious branching, rosetting and stunting in plants, and sometimes the upper portion of flowering stem even becoming thin, more upright and yellowish, followed by death in a few months. Since no effective control measures are available for viruses, viroids and mycoplasma, the infected plants should be uprooted and burnt. Regular spraying of the crop with malathion to control the insects which suck the cell sap and transmit these diseases will control these diseases.

Practical Exercise

Activity 1

Propagation of chrysanthemum by cutting.

Material required

Healthy chrysanthemum plant, secateur, IBA, water can, etc.

Procedure

- Select the terminal branches of a healthy plant for cutting.
- Terminal tip cuttings of 5–8 cm long are cut with the help of secateur.
- Remove basal leaves and half of the other open leaves.
- Base of the cutting is dipped in IBA 500 ppm or Seradix.
- Plant the cutting by inserting them 3–5 cm apart in sand beds.
- Immediately after planting, light watering with fine rose can should be given.
- Irrigate it regularly daily until 3–4 weeks.

Check Your Progress

A. Fill in the Blanks

1. Pinching in chrysanthemum is done by _____ of the growing tips of the plants at _____ stage.
2. Standard chrysanthemum is harvested when _____ but before _____ begins to elongate.
3. Chrysanthemum is commonly known as _____ or _____.
4. Chrysanthemum flowers, which have invisible disc, are _____ and _____.
5. Chrysanthemum can be commercially propagated by _____ and _____ cuttings.

B. Multiple Choice Questions

1. The critical day length required for flower initiation and flower development of chrysanthemum is —
   (a) 14–15 hours and 13–14 hours
   (b) 11–12 hours and 12–13 hours
   (c) 10–11 hours and 9–10 hours
   (d) 16–17 hours and 15–16 hours
2. Chrysanthemum can be grown on the soil pH of about —
   (a) 7.5
   (b) 6.5
   (c) 5.5
   (d) 4.5
3. Terminal or tip cuttings of _____ for chrysanthemum should be taken from a healthy stalk.
   (a) 7–10 cm
   (b) 10–15 cm
   (c) 5–8 cm
   (d) 15–20 cm
4. _____ are used to control the outside growth of heavy bloomers pots plants of chrysanthemum.
   (a) 7–10 stakes
   (b) 10–12 stakes
   (c) 1–2 stakes
   (d) 3–5 stakes
5. Removal of suckers from the base of chrysanthemum is known as _____ .
   (a) de-suckering
   (b) pinching
   (c) stopping
   (d) disbudding and de-shooting
6. _____ is the removal of the growing tips of plants at 10–15 cm stage which results in the production of several lateral shoots.

(a) De-suckering
(b) Pinching or stopping
(c) Disbudding
(d) Topping

C. Subjective Questions

1. How the varieties of chrysanthemum are classified?

   _____

   _____

2. Write about the vegetative propagation of chrysanthemum.

   _____

   _____

3. What is disbudding in chrysanthemum?

   _____

   _____

4. Write about staking in chrysanthemum and give its advantages.

   _____

   _____

D. Match the Columns

A	B
1. Cuttings	(a) Invisible disc
2. Pompon type chrysanthemum	(b) Terminal 5–8 cm long healthy stalk
3. Standard variety	(c) Mahatma Gandhi
4. Single type chrysanthemum	(d) Strap-like ray florets

Session 3: Cultivation of Tuberose

Tuberose: *Polianthes tuberosa*

Family: Agavaceae (formerly called Amaryllidaceae)

Tuberose is an important bulbous ornamental plant with true bulbs as the propagating material. It occupies a very prominent position due to its fragrant white flowers and for its use as loose or cut flowers, for making garlands and in various floral designs as well as in perfume industry. This is an ornamental plant, which can be grown in temperate areas of the country during summer by planting in March–April. It can also be grown in tropical areas of the country by planting

Fig. 1.10: Tuberose

in September–October, and in the sub-tropical areas of the country by planting during February (Fig. 1.10).

Cultivars

On the basis of the number of rows of petals in a flower, tuberose varieties are classified into three types:
Single : Bearing single row of petals
Semi-double: Bearing 2–3 rows of petals
Double: Having fully double flowers
Single and semi-double ones last longer with strong fragrance than the doubles, as opening in the singles is comparatively much better while in doubles, it is poor. In tuberose, yet there are only ten single varieties in existence such as *Arka Nirantara*, *Bidhan Snigdha*, *Snigdha Ujjwal*, Hyderabad Single, Mexican Single (Calcutta Single), *Phule Rajani*, *Prajwal*, *Rajat Rekha*, *Shringar*, and Sikkim Selection (semi-double); while the doubles are only four, and these are Mexican Double (The Pearl or Calcutta Double), *Suvasini*, *Swarna Rekha*, and *Vaibhav*.

Climate

Tuberose grows well in the tropics throughout the year, in subtropics it is planted in February for best results, and in the temperate regions of the country it is planted during March–April. The commercial cultivation is mainly confined to warm and humid areas with temperature range of 20 to 35°C where plenty of sunlight is available. A high temperature of 40°C, as well as, low temperature of 10°C is reported to reduce spike length, weight, and quality of flowers. A temperature range of 20–30°C is found to be optimum for maximum bulb production.

Soil

Tuberose can be grown in a variety of soils at a fully exposed site, rich in organic matter, well aerated, water-retentive but not waterlogged and whose pH is 6.5–7.5, though performance is excellent in sandy loam to loamy soils. Under filtered situation, the plants become lanky with shy blooming habit, though under complete shade, there is no flowering at all.

Propagation

A few of the single varieties set seeds. Seed propagation is a very slow process and is meant only for the evolution of new varieties. From flowering to seed maturity, it takes about two months, and the shining black seeds are collected after maturity from the capsules, dried, and then sown in sandy-loam soil, which normally takes three seasons to attain the flowering size.

Commercially it is multiplied only through healthy bulbs and bulblets formed around the main bulb. A fully developed bulb forms 15–30 bulblets in one season by which, if properly cared, attain flowering size further in one growing season; though if retained with the mother bulbs, these may require 3–4 seasons for full development. The bulbs are spindle-shaped, and if attained 2–3 cm diameter, these are quite suitable for taking the flower crops. It is better to avoid fresh bulbs, as it will result in more vegetative growth. Bulbs stored for 4–6 weeks after harvest are ideal for planting.

The size of the bulbs plays an important role in growth and production. Although, larger bulbs result into slightly delayed sprouting but flowering is not delayed, and instead higher spike yield *vis-à-vis* loose flowers, is obtained.

Preparation of land

The land should be free from weeds and has to be thoroughly ploughed three times, followed by planking each time; all the hard materials and the rootstocks of all the perennial weeds, especially the *doob* grass and the rhizomes of nutsedge, along with polythene shreds, wood, brick and stone pieces should be taken out, and soil has to be brought to a fine tilth, properly levelled, and partitioned into various beds of convenient size keeping the provision for water channels and bunds. Since the cropping is perennial at least for three years, so every year this will have to pass through the rainy season, so proper slope will have to be given for draining out the rain water.

Notes

Planting

The planting time varies from place to place depending on climatic conditions. It is planted during February–March in the plains of subtropical regions, such as Delhi during March–April on hills having temperate climatic conditions, during July–August in parts of South India, and during April–May under Bengaluru conditions. These are generally planted on flat beds having a slope to one side to drain out the excess water during rains to avoid waterlogging. Since this is planted for a perennial cropping, so ridge planting becomes redundant.

For harvesting the flowers, it is preferable to have 30 × 30 cm, or better if the distance is kept 40 × 40 cm for perennial cropping so that afterwards there may not be any problem of space. However, for bulbs the spacing may be kept at 20 × 10 cm, 20 × 15 cm, 20 × 20 cm and 20 × 30 cm; looking at the size of bulbs, smaller ones require a high density while larger ones, poor. For one hectare of planting, some 5 lakhs of small bulblets are required, though for flowering it is 60,000 for perennial cropping, and one lakh bulbs when the crop is for 1–2 years.

Planting depth is normally 4–8 cm, it is utterly deep in sandy-loam soils while quite shallow in clayey soils, though size of the bulbs also plays an important role for depth of planting because smaller bulbs require shallow planting as compared to larger bulbs.

Manures and Fertilisers

At second ploughing, 20–30 tonnes of well-rotten compost should thoroughly be mixed in the soil. Nitrogen at 200 kg/ha and phosphorus fertilisation at 60 kg/ha is most necessary in case of tuberose as these help in vegetative growth, leaf development, bulb production, and flowering, though potassium is not as important, if the soil is not deficient, however, soils having low potassium should be supplied with 50 kg/ha. Excessive use of any element is harmful, as excess of N causes taller and soft spikes, which can break during light winds and become more vulnerable to insect-pests and pathogen attack, *vis-à-vis* flower quality also becomes poor. Nitrogen deficiency is expressed as a typical

paling of foliage, less number of florets per spike, and less number of spikes per plant. Phosphorus deficiency causes reduction in growth and flowering, upper leaves become dark green but lower ones turn purple. Calcium deficiency causes cracking of spike and bud rot. Magnesium deficiency exhibits interveinal chlorosis on older leaves and iron deficiency on the new leaves. Boron deficiency causes stunting in the inflorescence, leaf deformity, and cracking of leaf margins. Manganese deficiency is expressed as yellowing of leaves between the veins. To avoid these problems, a mixed micronutrient fertiliser should be applied to soil before planting.

Irrigation

The available soil moisture markedly influences growth and flowering. The soil type, weather condition, and stage of growth, all influence irrigation frequency. At the time of bulb planting there should be sufficient moisture in the soil up to the sprouting of the bulbs, and when these have sprouted, first irrigation is given. Subsequently, in light soils it should be given weekly, and in heavy soils at an interval of 10–12 days. During summer, the frequency of irrigation is more as compared to winter. However, when the crop is over, the watering is almost withheld so that the bulbs are forced to go into dormancy and these may be quite fresh in the next cropping season. After the use of every fertiliser, watering is must.

Weed control

In any crop, weed is a menace as it robs the crop of its nutrients, moisture, sunlight, *vis-à-vis* aeration, and lack of aeration encourages the development of diseases and pests in the crop. Generally, in India only hand weeding is done through our antiquated handy tool *khurpi*, however, in large plantings 1.5 l/ha of pendimethalin or 3 kg/ha of kraft atrazine is quite effective, pendimethalin as pre-emergence spraying (diluted in water to wet one hectare of land) in the field while Atrazine is used as a pre-plant herbicide. Their use increases the quality spikes, as well as the bulbs and bulblets. Covering the field with 5–8 cm top layer

with mulches such as chopped bagasse, dry leaves, straw, rice husk, sawdust, various types of oil cakes, and groundnut husks not only checks the growing of weeds, but after decomposition also provides organic manure to the field in a course of time. Black polythene mulch is very effective in checking weed germination, but it does not decompose.

Harvesting of flowers and yield

Flowering starts three to four months after planting. Loose flowers are harvested one by one as these are used for making garlands and other floral ornaments while for bouquets and vase arrangement the spikes are cut from the base. The ideal stage for cutting spikes is when the first pair of flowers is fully open. Immediately after harvest the spikes are kept in distilled water. Picking of flowers is to be done during cool hours of the morning or evening. About five people are required to harvest 60 kg of flowers in two to three hours. Once planted, the crops can be harvested successfully for three years especially for loose flowers. An average of 12–15 tonnes of loose flowers per hectare can be obtained while 100,000–125,000 spikes can be obtained from per hectare of area.

Harvesting of bulbs and storage

At the end of every third cropping, the bulbs should be lifted. When the flowering is over and the plants have started yellowing, it is the time to start the bulb harvesting. The watering should be adjusted in such a manner that there is sufficient moisture for lifting of bulbs. The soil around the plant is loosened with the help of a spade or digger, the whole clump is taken out, the aerial part of the plant is twisted off, the bulbs are cleaned and shade-dried, and then stored in a well-ventilated place under room condition for three months. The yield of bulb is dependent on the cultivar used, the soil type, the environmental conditions, and size of the bulbs planted. Normally, 40 × 40 cm planting of 2.5–3.0 cm diameter of bulb produces about 25 tonnes of bulbs in three year cropping. The bulb yield in one year of cropping is usually 10–12 tonnes.

Insect-pests

Grasshoppers *(Hieroglyphus spp.)*

These pests are highly devastating on young leaves and emerging flower buds, especially during the rainy season. For their control, 0.2% methyl parathion or dimethoate spraying is quite effective.

Weevils

The adult feed in the darkness on the leaves making notches on the edges which may be trapped and killed as they are less in number. Their larvae feed on the roots and tunnel into the bulbs whose attack may be prevented by applying furadan granules at 3–4 kg/ha at the time of bed making. Dimethoate spraying at 0.2% will control the weevils effectively.

Aphids *(Aphis spp., Myzus persicae)*

These are very small in size and multiply rapidly. They feed on the growing points and floral buds which maybe controlled by spraying nicotine solution. Dimethoate spraying at 0.2% is quite effective against aphids.

Thrips *(Taeniothrips spp.)*

These are minute insects which suck the sap of the leaves, buds, and flowers, and act as carrier agent in causing 'bunchy top' disease where the inflorescence is malformed. While controlling the grasshopper, this will also be controlled. Dimethoate foliar spraying at 0.2% will control the thrips.

Red spider mites *(Tetranychus telarius)*

These suck the sap on foliage causing yellow stripes and streaks, and in severe cases leaves turn yellow, silvery, or bronze and finally get deformed. Kelthane spraying will prevent its infestation.

Nematodes

Aphelenchoides besseyi causes greasy streak on foliage and *Meloidogyne* spp. (*M. incognita, M. javanica, M. arenaria, M. acrita*) causes root galling, poor growth of plants with the leaf tip burn and yellowing, and suppressing spike emergence in their severe infestation. Bed fumigation and post-planting drenches with methyl bromide will rid the plant of these pests.

NOTES

Diseases

Stem rot (*Sclerotium rolfsii*)

It is caused at the soil level. Leaves lose their greenness, the whole leaf rots and gets detached from the plant. Due to its infection, round and brown sclerotia are formed on and around the infected leaves. Ultimately, the plants become too weak to produce flowers. Mercuric chloride 0.1% and commercial formalin 0.2% have excellent control of the disease. Dusting 20% brassicol has been found quite effective. Drenching soil with zineb (0.3%) or thiram (0.2%) thrice at 20 days interval has been found quite effective for controlling stem rot.

Botrytis spots and leaf blight *(Botrytis elliptica)*

It is a problem under cool-cum-moist growing conditions. Initially when it is noticed, 0.2% weekly maneb spraying should be followed and the field humidity should be kept under check. Before planting, the bulbs should also be treated by dipping them for one hour in 0.2% captan. Ammonical copper at 0.2% spraying fortnightly is quite effective in controlling leaf blight.

Alternaria leaf spot *(Alternaria polyanthi)*

It is also seen on tuberose leaves. It is controlled through spraying of 0.2% mancozeb at 10 days' interval.

Flower bud rot *(Erwinia carotovora)*

It is sometimes observed on the floral buds which may be controlled by spraying mercuric chloride or streptocyclin at 0.01%.

Leaf mottling

It is caused due to a virus. Such plants should be destroyed to check further spread.

Practical Exercise

Activity 1

Identification of different types of tuberose with their characteristics and varieties.

Material required

Pen, pencil, notebook, tuberose, etc.

Procedure

Note down the observations in the table given below.

Type	Characteristic	Varieties
Single		
Semi-double		
Double		

Check Your Progress

A. Fill in the Blanks

1. Commercially, tuberose is propagated by _____.
2. Semi-double flowers of tuberose bears _____rows of petals.
3. A fully developed bulb of tuberose forms _____ bulblets in one season.
4. Tuberose flowering starts after _____ months of planting.
5. The bulb of tuberose is _____ shaped.

B. Multiple Choice Questions

1. Long flower spike tuberoses are mostly used as —
   (a) cut flowers
   (b) table decoration
   (c) bouquet preparation
   (d) All of these
2. Planting time of tuberose in tropical areas of the country is _____.
   (a) September–October
   (b) December–January
   (c) March–April
   (d) June–July
3. Temperature range for commercial cultivation of tuberose is _____.
   (a) 20–35°C
   (b) 35–45°C
   (c) 15–20°C
   (d) 10–15°C
4. Tuberose bulbs should be stored for _____ weeks after harvest.
   (a) 2–3
   (b) 4–6
   (c) 6–8
   (d) 8–10

5. The yield of tuberose bulbs in one year of cropping is usually —
   (a) 6–8 tonnes
   (b) 8–10 tonnes
   (c) 10–12 tonnes
   (d) 12–14 tonnes

C. Subjective Questions

1. What are the different types of tuberose flowers?

   _____

   _____

   _____

2. Explain the planting of tuberose.

   _____

   _____

   _____

3. How and when tuberose can be harvested?

   _____

   _____

   _____

4. Explain the insect pests and disease management in tuberose.

   _____

   _____

   _____

5. Explain Stem rot disease of tuberose.

   _____

   _____

   _____

D. Match the Columns

A	B
1. Typical paling of foliage	(a) Yellowing of leaves in between the veins
2. Phosphorus	(b) Boron
3. Calcium	(c) Interveinal chlorosis on the new leaves
4. Cracking of spike and bud rot	(d) Magnesium
5. Iron	(e) Interveinal chlorosis on older leaves
6. Stunting in the inflorescence	(f) Upper leaves become dark green and lower ones purple
7. Manganese	(g) Nitrogen

Session 4: Cultivation Technique of Gladiolus

Gladiolus: *(Gladiolus hortulanus/ G. hybridus)*

Family: Iridaceae

Gladiolus is one of the leading geophytes grown worldwide for cut flower trade and garden displays. It attracts viewers by its magnificent inflorescence, and wide array of colours, shapes, and sizes of its flowers. Its florets open from bottom to upward one by one and a good spike lasts for more than 10 days in ordinary water during winter (Fig.1.11).

Fig. 1.11: Gladiolus

Varieties

American Beauty (reddish-pink), Anglia (yellow), Applause (deep pink, throat red), *Archana* (orange), *Bindiya* (pink), Blue Sky (violet-blue), *Chirag* (yellow), *Dhanvantari* (light yellow), Eurovision (deep red), Friendship (carmine-rose), Gunjan (light pink), Her Majesty (deep violet), Hunting Song (scarlet-red), Jacksonville Gold (light yellow), Jester (deep yellow), Lohit (coppery), Mascagni (bright red), Novalux (yellow), Oscar (signal-red), Peter Pears (orange-red), Priscilla (pinkish-mauve), Ratna's Butterfly (orange), Rose Spire (light pinkish-mauve), Rose Supreme (light pink), Sancerre (white), *Suchitra* (light pink), Sylvia (red), True Yellow (yellow), Urmil (violet), White Prosperity (white), Wind Song (purplish-mauve), Yellow Stone (sulphur-yellow), etc.

Propagation

Gladiolus is propagated through corms and cormlets, though for evolution of new varieties, seed are used. In normal course, seed propagation is not advised as it provides varying colours in the progeny, and takes about three years to reach the flowering size. Cormlets (cormels) are the potent source for its multiplication as a plant and may produce from a few to 1000 cormlets, which when planted after removing the tunic, sprout along the corms and grow well, provide healthy stock and well-crowned corms. The corms are generally used for production of flowers so in the end of the season, one to eight corms may be formed underground depending upon the cultural practices followed, the climatic conditions prevailing, and the type of variety used. Though planting of injured corms in the plains is a high risk, so fractionated corms cannot be used as planting stocks here but in temperate areas these can be used after treatment with some effective bactericide and fungicide. Nowadays, micro-propagation is getting popularity to get disease-free corm and cormlets, which are used as propagating material at commercial level.

Climate

In India, it is grown during summer in temperate areas and in the subtropical areas during winter. Though winter temperature in the plains is not so congenial therefore spike size is smaller in the plains than those grown in the hills. Gladiolus prefers a fully sunny condition as it is a long day plant. If atmospheric humidity is high, its flowers grow well up to 50°C, however, usually it grows well in 16–35°C temperatures.

Soil

Though it tolerates a large variety of soils but well-drained sandy-loam soil rich in organic matter is the best for gladiolus cultivation. Heavy soil is not quite preferable. It grows better on fairly acidic soil having a pH of 5.5–6.5, though these can be grown successfully in soil having pH up to 7.5. Waterlogged soil should be

avoided for its cultivation. Rain is not favourable during flowering as flowers get damaged, therefore if cultivation is done during rains, its spikes require to be protected.

Land preparation

Gladiolus should be grown in a levelled field in a sunny condition which is devoid of perennial weeds because such weeds make compaction of the soils and their rootstocks hinder the cultivation practices. Green manuring with *sunhemp*, *dhiancha*, moong, lupins or other leguminous crops can be used before planting. First ploughing is done to a depth of 30 cm, and if need be it may be sown with the seeds of some green manuring crop, followed by planking, and then the field is left as such for one month for proper growth of the cover crop, however, the green manure crop is to be irrigated regularly. The second ploughing is done when the green manure crop has attained up to 60 cm height, that is, 30–45 days of growth and 3–4 weeks before planting and then it is knocked down followed by incorporation of 20–30 tonnes of farmyard manure or compost and flooding so that green manure crop is fully decomposed, and FYM is also fully mixed up with the soil. At planting, there should be sufficient moisture, so that, until sprouting of the corms, there may not be any necessity for watering, otherwise, soil-borne pathogens enter the corms. One should ensure that at third (final) ploughing, all the stubbles, rootstocks of perennial weeds, such as, *nutsedge* and *doob* grass are taken out along with other hard foreign materials and polythene shreds so that the soil becomes fully pulverised. At this time, 6.25 q/ha of single superphosphate and 1.7 q/ha muriate of potash should evenly and thoroughly be mixed in the soil. Now the soil is properly levelled, and then after the beds of convenient sizes are prepared along the bunds, channels, and sub-channels for convenience of field operations and watering.

Planting

It is an open field cultivated crop, being grown during winter in the subtropical and tropical conditions, and

during summer, in the temperate regions, however at places, such as Bengaluru, it can be grown throughout the year. Corms are planted for the purpose of flowers, and cormlets for further multiplication to have healthy stock for the next planting season, therefore, both should be planted separately. It would be better if one week prior to planting, the corms and cormlets are dipped in 0.2% solution of captan, followed by shade-drying to avoid penetration of any germ in the corm, whether present on the corm or in the soil. Diseased or infested corms or cormlets should be discarded and only healthy stocks should be planted. On the basis of the spherical diameter, the corms are classified into large (>5.1 cm), medium-large (3.8–5.0 cm), medium (2.5–3.8 cm) and small (<2.5 cm) groups and various sub-groups. These groups produce varying spike length, floret number per spike, flowering duration, and number and weight of corms and cormels, etc., so they require varying planting distances. Different cultivars require different size of corms for best performance. However, in general, a corm with 4.5–5.0 cm diameter and more than 40 g weight has been ascertained to be moderate for producing best quality blooms, corms and cormels. Larger corms take a shorter period to bloom as compared to smaller ones. The late-flowering varieties produce more corms with larger cormlets while early-flowering ones produce corms with smaller cormlets.

Time and depth of planting and spacing

September–October in the plains and March–April in the hills is the optimum time for planting of gladiolus, whereas in Bengaluru climate, planting can be done round the year.

Generally, a planting depth of 7–15 cm is suggested. Larger corms as well as lighter soil require deeper planting depth as compared to smaller ones and heavier soil condition. While planting, care should be taken that soil has sufficient moisture and the corms are planted with the right side placed upwards. In normal soil, the corms are planted at a depth that is double of their polar diameter. Deeper planting causes poor contractile root formation, and the plants remain stronger and taller

but corm and cormel formation is poor, while shallow planting causes precocious contractile root formation with a good multiplication of daughter corms and cormlets though spike size is smaller.

Planting density is basically dependent upon the size of the planting material, season of growing, and soil type. It is advisable to plant gladioli in double-row system, where two rows of corm planting will have to be done in each line, distance being 15 cm from one row to another in a line, and the corms are put alternatively in each row, though distance from one 2-row line to another 2-row line in the bed is kept 40 cm for the convenience of cultural operations. Corm to corm distance in a row is maintained at 10–15 cm (larger corms requiring larger space than the smaller ones), thus some 40 corms will be accommodated per square metre of the bed-area, and in one hectare some 1,68,000–2,68,000 corms will be accommodated after excluding one-third of area for bund cum furrow making. In temperate areas, only high density should be maintained as it is grown there during summer when climate is highly congenial, the soil is sandy loam, highly porous, and slightly acidic, so all these factors collectively contribute to the harvesting of a good crop with respect to spike size as well as for corm and cormel production.

The method of planting is quite simple. The lines in the beds are marked at 55 cm distance, and while planting, the corms are swiftly kept at specified distances at both the sides of each line (distance from one side to the other of the line being 15 cm) in each bed. Then, from in between the lines, the soil is taken through a spade to cover the corms which will form the automatic ridges and furrows. No direct watering to the plants is to be given but water is released only in the furrows, from where required amount of water is absorbed by the individual plants and this way there would not be any waterlogging problem also, *vis-a-vis* which will enable the grower for easy cultural operations.

Manures and fertilisers

Gladiolus requires both macro and micronutrients for its growth. In light soils, nitrogen is applied in three

split doses, that is, — (i) at planting, (ii) side-dressed after the development of 2–3 leaves, and (iii) at the time of spike emergence. In heavy soils, it requires two split applications, viz. at the time of planting and after 45 days. Full doses of P_2O_5 and K_2O are applied at the time of planting. If spikes are found to be smaller, it will not give proper remuneration in the market, at the time of spike swelling stage, 70 g/m^2 of urea should be applied immediately followed by watering. However, urea dose should never be repeated otherwise corm size will become very poor. Fertiliser dose also varies with different regions and it is essential to conduct soil nutrient analysis before the fertiliser application. To obtain higher yield of corms, the cormels are supplied with 500 kg/ha of nitrogen and phosphorus each. Full dose of phosphorus should be applied at the planting time of cormels, whereas nitrogen has to be given in three equal splits, that is one-third at planting time, one-third at 60 days after planting, and remaining one-third at 90 days after planting.

Irrigation

To avoid irrigation before sprouting, it would be better to irrigate the field lightly at third ploughing so that at planting time there is sufficient moisture in the field. This minimises disease occurrence. Lack of moisture in the soil will delay sprouting so one should ensure that soil contains sufficient moisture at planting. First watering is provided once all the corms have sprouted. The frequency of irrigation depends on the weather condition, soil type, and rainfall. During warm weather, watering should be done superficially after every five days, whereas in cold weather once in 10–12 days. When the plants attain a height of 20 cm, they should be hilled up to the height of 10–15 cm. This enables the plants to grow erect even during high winds and severe rains.

Weed control

Gladiolus requires weeding twice in a month, and as it is a roughly six month crop so before three months of flowering, initial four months require routine weedings.

Though in India, only manual weeding is practised but it is quite expensive, and there are chances of damage to the plants which gives an opportunity for entry of the pathogens through wounds inflicted, if any. No system in India is developed for mechanical weeding in gladiolus field, hence an efficient system of chemical weeding is the only option. First, weeding is carried out within four weeks of planting, second weeding during top dressing, and rest as per the requirement. Pendimethalin (Stomp) at 1.25 kg a.i./ha can be used as a pre-emergence weedicide to control weeds in the field up to 75–80 days after planting. After planting of the corms, pendimethalin is diluted in water and sprayed over the whole planting at one stretch sufficiently to wet upper layer of the soil.

Staking

Varieties producing taller spikes require staking with bamboo or willow sticks to save them from breakage due to lodging or winds. One stick is inserted some 10–15 cm away from plant base so that forming corm is not damaged. The stakes should be inserted when swelling of spike has started, and then the plant should be loosely tied with the stake to a height of about 30–40 cm. Second tying should be carried out at 50–60 cm height when the flowers in the spike have started swelling. Alternatively, the beds should be pegged at each corner and 3-tier strings should be stretched all around the bed and in between the plants, so the plants could be saved from wind damage or lodging.

Growth regulators

Application of growth regulators like GA_3, IAA, NAA, CCC, B-Nine, etc., as soil drench or foliar application improves the growth and flowering of plants and induces earliness. Soaking of corms in GA_3 at 250 ppm increases sprouting, improves subsequent growth, and production of flowers. Prolonging the storage life or delaying the sprouting of the corms with the application of higher doses of ethrel (ethephon) is a common practice provided the temperature is not a limiting factor. Growth promoters like GA_3, NAA, kinetin, etc., at a concentration of 10–50 ppm enhance sprouting.

Harvesting and yield

In gladiolus, florets are borne alternatively on long slender spikes. These spikes are harvested for cut flowers. The quality of spikes is judged by the length of spike, the number of florets per spike, number of florets opening at a time, number of florets remaining open at a time, the arrangement of florets on the spike, floret colour, size, and texture (simple and thin, leathery and folded, frilled or ruffled, etc.). An ideal spike should be in tight bud stage with three to four buds showing colour so that these may easily open one by one in the vase. While harvesting, there must be four to five leaves left on the plant which will help further the corm development in the subsequent period as still the corm and cormel development takes place.

Generally, one plant produces single marketable spike and 1–3 plantable corms and a few-to-many cormlets. Roughly the production of spike is double the number of the planted corm provided the planted corm is of a large size.

Post harvest

For local markets, the spikes are removed when the first batch of florets have started opening, however, for distant markets the proper stage for cutting is when the first batch of florets has started showing colour. The spikes are harvested mostly early in the morning, leaving atleast four leaves intact on the mother plant, and the cut ends are immediately placed in a bucket containing palatable water. For transportation, these survive dry for up to two days. The cut spikes are taken to the packing shed where these are pulsed with 20% sugar + 200 ppm 8-HQC for 24 hours. If needed, these can be stored dry for up to two weeks at 1°–2°C. For local markets these are packed in a bundle with 12 spikes each, and then wrapped in newspaper, and then finally some such 25 bundles are packed with hessian cloth for transportation to the nearest market. For distant markets, the spikes are packed in 100 × 25 × 10 cm perforated cardboard boxes. However, the packing should be done when no part of spike surface is wet to avoid botrytis infection during transportation.

Harvesting or lifting of corms, curing and storage

The corms and cormlets are lifted after 45 days of flower cutting as by this time all the corms and cormels have matured. When 25% cormlets have changed to brown colour, it is a sign of maturity. At lifting, there should be sufficient moisture in the soil to facilitate proper lifting, though in no case the soil should be wet. The adjoining soil to the plants is loosened by spade, shovel, or *khurpi*, the plants are gently pulled out of the soil one by one, the adhering soil is knocked down so the corms and cormlets are completely clear of the soil, all the cormlets at this time are attached with the corms with their stolons so these should also be taken out one by one, the aerial plant is twisted off without injuring the corms, and then finally, the mummified remnant of the planted mother corm is also twisted off through thumb and fingers. All the daughter corms of one variety are placed in small cloth or perforated nylon bags, labelled, and then kept in an aerated room for curing. All the cormels of one variety are also placed in the cloth bags, labelled, and kept separately for curing. After a fortnight, the corms and cormlets are treated by dipping for one hour in 0.2% captan solution, and then again dried in the same room at least for one month. All these varieties, after perfect curing, are either placed in crates or in gunny bags and put in cold storage at 3°–7°C temperature and 68–75% RH at least for two months. By September end these should be taken out from cold storage and thinly spread in a room for acclimatisation, and then again dipped in 0.2% captan for one hour, and then again dried, and by this time (mid-October) the field should be ready for transplanting in the plains. In the hills, cold storage treatment is not necessary as the corms and cormels can be stored at room temperature effectively.

Pests

Aphids *(Aphis gossypii, Macrosiphum euphorbiae, Myzus persicae)*

These are very harmful pests of gladioli, especially during hot and cloudy weathers, and these continue sucking the sap from tender plant parts and flowers by

NOTES

clustering there. These also act as vectors for the dispersal of viral diseases so viral infection can be brought to the minimum by controlling these pests. Spraying the crop with imidacloprid 17.8% SL at 250ml in 500 litres of water per hectare or 100ml ranxypyrex in 500 litres of water/ha will kill these pests.

Thrips *(Taeniothrips simplex, Frankliniella occidentalis)*

With their light yellow nymphs and adults, these can be found moving on gladiolus plants everywhere, especially on the buds and flowers and rasping the sap of the tender parts. Spraying with sevin 0.2% or methyl parathion 0.1% will kill these pests.

Borer *(Helicoverpa armigera)*

It is a polyphagus insect which feeds on every part of the plant. Spodoptera litura and Trichoplusia semilooper also have been found feeding on gladiolus leaves and flowers, and when disturbed, the semilooper hangs itself through a thread on the plant. Thiodan 35 EC at 0.5 % spraying will kill the larvae of these insects.

Cutworms *(Agrotis ipsilon),* ***and whitegrubs*** *(Phyllophaga spp.* and *Poppillia spp.)*

These feed on underground gladiolus corms and roots. Underground pests can be controlled through the use of furadan granules mixed in the soil at the time of field preparation.

Mites *(Rhizoglyphus echinopus, Tetranychus urticae)*

These are yellowish-white with a pink tinge which feed generally on the undersurface of leaves but in their severe infestation, these are observed everywhere on the plants. Their infestation is favoured by warm and shady conditions. Dichlorvos smoking in the greenhouse is very effective in controlling these pests. Kelthane 25 WP at 2 g/l also controls the mites.

Mealybugs *(Pseudococcus maritimus)*

These feed on the base of the corms in the field and suck their sap. In the storage when temperature is above 15°C, these multiply rapidly, feeding on

the corms which cause the corms to shrink. Lysol soaking of corms for three hours will control the mealybugs. Azadirachtin, chlorpyrifos, bendiocarb, or acephate spraying on the corms is also effective.

Nematodes *(Meloidogyne incognita and Trichodorus species)*

These have been found infesting on gladiolus roots by galling them which causes the plants to become stunted with poor growth. Soil fumigation and hot-water treatment of dormant corms at 53°C for half an hour will kill these pests. These are also controlled by application of aldicarb, furadan or nemagon.

Diseases

Storage rot *(Penicillium gladioli, Rhizopus arrhizus)*

It occurs due to excessive humidity or more than 5°C temperature in the storage, and storage of improperly cured or injured corms. Corms and plants treated as suggested under fusarium infection will rid of this problem also, however, the storage condition should be proper.

Fusarium wilt

Fusarium oxysporum f. sp. *gladioli* and *F. orthoceras* var. *gladioli* are responsible for this disease. In the field, these show plant yellowing, and bending to one side as the disease attacks the vascular system and from such infections corms cannot be saved if once infected. Use of benomyl at 0.1% alternately with captan at 0.2% fortnightly to the standing crop, and corm dipping for one hour in 0.2% captan after lifting and before planting will give an assurance for a healthy crop.

Botrytis blight and floral rot *(Botrytis gladioli, B. cinerea)*

It occurs when the weather is very cold, windy and cloudy. If immediately after its appearance, weather becomes dry, the tip of the flower bud also dries up so flowers do not open but when the weather is humid, the flowers become watery, and the whole crop is destroyed as if burnt. Regular spraying with maneb or benlate at 0.2% during inclement weather conditions, at weekly interval will keep this problem under check.

Leaf spots *(Alternaria alternata, Curvularia lunata, C. trifolii and Septoria gladioli)*

These occur on gladioli in various forms such as tip and side burning due to *Alternaria*, sides towards the tip start drying with a frog-eye like appearance due to the infection of *Curvularia*, and there are brown circular spots on older leaves, late in the season, which later on may coalesce and exhibit shot-holes due to infection of *Septoria*. All these problems can be solved by applying 0.2% maneb sprays.

Bacterial scab, neck, or stem rot *(Pseudomonas marginata, P. gladioli* pv. *gladioli)*

It appears in the form of raised reddish specks at the base of the plant initially but afterwards fleshy basal parts rot with falling of the leaves. Corms show water-soaked pale-yellow circular lesions which afterwards turn brown to black and exude a gummy substance. Such plants should be destroyed. To avoid the plants being infected with this disease, the corms should be dipped in $HgCl_2$ solution after lifting and before planting.

Bacterial blight *(Xanthomonas gummisudans)*

It is a serious problem on gladiolus on poorly drained soils, *vis-à-vis* wet climatic conditions, and initially its infection causes irregular water-soaked lesions on the corms which later on turn brown and dry up where leaves also become affected afterwards. Infected parts release a slimy exudate, so these plants should be removed from the field. Before planting and after harvesting, the corms should be dipped in $HgCl_2$ solution, and care should be taken to avoid waterlogging.

Cucumber mosaic virus (CMV)

On gladiolus plants, it appears as the discrete lighter streaks on the leaves. Its infection does not have any adverse effect on gladiolus plants as it is not visible on plant or flowers, and no obvious adverse effect is visible on further vegetative generations.

Aster yellows

It is a serious problem in gladioli where straw-yellowing of the upper part of plant occurs, and the spikes show

twisting cum bending. Any plant observed in the field with these symptoms, should immediately be uprooted and destroyed to check its further dispersal.

Physiological disorders

Flower abortion (blasting) and blindness are the most common physiological disorders in gladiolus. These are primarily due to poor light conditions, especially in the winter crops. Sometimes, etiolated plants are observed in greenhouses. This may be due to the imbalanced relationship between light and temperature.

Fluoride injury is a very common phenomenon in gladiolus plantings and even at 1 ppb level, it expresses the effect of fluorine. The effect is expressed in the form of tip burn on leaves. Fluoride toxicity can be reduced by spraying 5% lime or magnesium sulphate.

Crooked stem

Though it is not a common problem but sometimes when the temperature is too high or the fluctuation is too frequent, the stems get crooked.

Practical Exercise

Activity 1

Demonstrate the planting of gladiolus.

Material Required

Corms are planted for harvesting flowers, and cormlets for further multiplication, to have a healthy stock for the next planting season.

Procedure

- Select a corm of 4.5–5.0 cm in diameter.
- Weight of the corm should be 40 g or above.
- It should be healthy and without injury.
- Dip the corms in 0.2% solution of captan for one day prior to planting.
- The lines in the beds are marked at a distance of 55 cm.
- The corms are kept at specified distances on both sides of each line (distance from one side to the other of the line being 15 cm).
- The soil in between the lines is taken through a spade to cover the corms (a planting depth of 7–15 cm is suggested) which will form ridges and furrows.
- Space between two rows should be 40 cm, and within the row it should be 15 cm.

Check Your Progress

A. Fill in the Blanks

1. One of the leading geophytes grown for cut flower trade and garden displays is _____.
2. Gladiolus is propagated through _____ or _____.
3. Gladiolus plant may produce up to _____ cormlets.
4. Corms or cormlets of gladiolus can be planted up to the depth of _____ cm.
5. Single plant of gladiolus produces _____ marketable spike and _____ plantable corms.
6. In gladiolus, the qualities of spikes are judged by the _____ of spike.

B. Multiple Choice Questions

1. Gladiolus prefers _____.
   (a) fully shade weather
   (b) fully rainy weather
   (c) fully moist weather
   (d) fully sunny weather
2. A planting depth of _____ is suggested for gladiolus.
   (a) 7–15 cm
   (b) 15–20 cm
   (c) 20–25 cm
   (d) 25–30 cm
3. GA_3 is used for soaking of corms at a concentration of _____ to increase sprouting.
   (a) 250 ppm
   (b) 300 ppm
   (c) 200 ppm
   (d) 150 ppm
4. Growth promoters like GA_3, NAA, kinetin, etc., at a concentration of _____ ppm to enhance sprouting.
   (a) 5–10
   (b) 10–50
   (c) 50–100
   (d) 100–150
5. The most common physiological disorder in gladiolus is _____
   (a) flower abortion
   (b) fluoride injury
   (c) crooked stem
   (d) None of these

C. Subjective Questions

1. Describe the staking of gladiolus.

   _____

   _____

   _____

2. Explain the harvesting of gladiolus.

   _____

   _____

   _____

3. Explain the physiological disorders in gladiolus.

   _____

   _____

   _____

D. Match the Columns

A	B
1. Flower abortion	(a) High temperature or frequent fluctuation
2. Fluoride injury	(b) Deficiency of calcium
3. Topple	(c) Tip burn on leaves
4. Crooked stem	(d) Poor light condition

SESSION 5: CULTIVATION TECHNIQUE OF CARNATION

Carnation: *(Dianthus caryophyllus)*

Family: Caryophyllaceae

Carnation is the leading global cut flower grown under greenhouses in the lower hills or at places having mild climate in India. A highly pleasing clove-like fragrance emitted by its flowers, being light weight, having various colours, forms and sizes, having excellent keeping quality with the ability to easy rehydration and withstanding long distance transportation have made it the most favourite flower globally. It is a native of the Mediterranean region, and is being produced commercially in different countries, especially Columbia, Kenya, Israel, Holland, Poland, USA, France, Italy, Spain and Japan. India has

the potential for growing good quality carnation under protected cultivation, especially in the lower hills of Solan, Ooty, Kodaikanal; in higher hills such as Shimla, Srinagar, and Kullu under hi-tech polyhouses; and in areas having mild climate such as Pune, Bangalore, etc. Broadly these are of three types, viz. standard, spray, and miniature (Fig. 1.12).

Fig. 1.12: Types of Carnations

Commercial varieties

Standard types

Altetico (bicolour), Arthur Sim (fancy), Candy (yellow), Corso (pink), Cream Valencia (cream), Desio (red), Espona (red), Europa (orange), Exotica (yellow), Golden Cabaret (yellow), Hellas (yellow), Light Pink (pink), Master (red), Nikita (yellow), Orange Isac (orange), Orange Triumph (orange), Parade (white), Pink Corso (pink), Red Corso (red), Safari (bicolour), Scania (scarlet), Sonsara (white), Tanga (red), Venus (pink),White Candy (white), etc.

Sprays

Alister (red), Bagatel-Wesbag (white), Boreal (pink), Cotillon (bicolour), Darling Red (red), Durango (pink), Elsy (red), Etna (red), Excel (white), Fantasia (pink), Flash (pink), Furlana (orange), Galina (pink), 'Garfield (bicolour), Gaucho (bicolour), Hermon (white), Koreno (pink), Kortina (red), Sintonia (orange), White Lilia (white), etc.

Climate

Carnations like mild climate. Cultivation at 30° North and South latitude of equator is the ideal climate. For successful commercial cultivation, it should be grown only under cover but with ample sunshine, approximately 21.5 klux for at least 8 h/day as it is a quantitative long day plant. The locations having day temperature of 25°C and night temperature of 10°–18°C are quite suitable for growing it. It requires 50–60 per cent relative humidity and good air circulation. Carbon dioxide concentration in the greenhouses should be 300–700 ppm during cloudy days and 700–1,000 ppm on sunny days.

Soil

Waterlogged conditions are not suitable for carnation growing. A rich but light sandy-loam soil with a pH range of 6.0–7.5 is quite suitable for its successful cultivation. Clayey and silty soil can be amended by the incorporation of farmyard manure. Prior to carnation planting, the soil should be sterilised through solarisation or through the use of 5% formalin.

Propagation

Terminal cuttings are a potent source for its multiplication, therefore, healthy mother plants having good vegetative growth should be selected for taking cuttings. Such plants should be covered from November to February to protect them from winter damage. Once started, these continue to provide cuttings for a period of four months. The cuttings of 10–15 cm long, having at least three nodes, better if there are four to five pairs of leaves, are taken from the mother plant, their lower one to two pair leaves are removed and planted in sand bed or in cocopeat in mist chamber. Over-watering of cuttings should be avoided otherwise these will rot. Cuttings should be treated for up to 12 seconds with NAA 500 ppm, and then planted at 3 × 3 cm distance in trays, sand-beds, or propagating beds for better rooting. To avoid infection of various soil-borne pathogens, the rooting nursery beds should be treated with 0.2%

captan solution. For rooting, it would be better if the cuttings are raised in a polythene chamber where daily misting of cuttings will root them within 30 days in the temperature range of 20°–26°C. After rooting, the cuttings are shifted in a hardening chamber, that is, mini portable tunnel measuring 3×1.5 m, covered with hessian cloth or any other material for 50% shading, and the mixture should contain sand, FYM, rice hulls and ash. This chamber should have a fogging provision which should emit fog for 10 seconds after every 15 minutes, if it has a bright sunlight. Here it takes about three weeks, for the cuttings, to become ready for transplanting.

Exporting units have a provision of tissue culture to multiply elite carnation varieties in large number. For this, only apical shoot tips are taken though it can be micro-propagated even through stem nodes, leaves, petals, and anthers. It is a modified Murashige and Skoog (MS) medium which has been found suitable for its propagation. These are propagated through callus or by direct regeneration process by placing them at 25°C temperature.

Cultural practices

Commercially, perpetual (Sim) carnations are grown under protected structures with sufficient light (long days with over 16 hour lighting and 100 W bulb fitted 1.5 m high and spaced at 10.5 m), 10°–16°C night and 18°–23°C day temperatures, sufficient ventilation, 50–60% relative humidity, and from 700 to 1000 ppm CO_2 when there is bright light. Looking into these, polyhouse will have to be created where temperatures may be lowered during summers and temperatures and lighting may be raised during winters, fitted with fan and pad cooling system, vis-à-vis top and side vents for providing fresh air, with the provision of 1.2 m wide beds, and some 60 cm space for cultural operations in between beds. Portable tunnels of the dimension 3 m × 1.5 m × 1.5 m may also be used to protect open-cultivated crops during rainy season. Tunnels protect the crops against rain and increase the growing temperature during winter.

Bed preparation

Ground beds, raised benches, or pots with perfect drainage provision may be used for its cultivation. The soil should be incorporated with 30 tonnes/ha of farmyard manure or any other organic manure at the time of bed preparation and ploughed, followed by planking after taking out all the stones, brick pieces, wood pieces, polythene shreds, and rootstocks of all the perennial weeds, especially sedge and Cynodon grass. Then the ground is treated with 5% formalin and covered with black polythene for about one week, then exposed for about one week and then again the field is ploughed, after mixing thoroughly 6 quintals of calcium ammonium nitrate, 12 quintals of single superphosphate and 1.7 quintals of muriate of potash in the soil, and the soil is brought to a fine tilth. 15–20 cm raised beds having a width of 1.2 cm are now prepared with a 60 cm path in between for working. The field is now ready for transplanting.

Transplanting

For flowering regulation, one will have to make a schedule for continuous harvesting of flowers throughout the year as carnations usually flower in five to six months of transplanting under open conditions but under protected conditions these start flowering within four months. Carnations planted under North Indian weather during mid-September–November (the optimum planting time) start producing flowers from February to April, whereas in the hills as the ideal planting time is October to February, these start giving flowers from mid-April to mid-July, and in the areas encountering snowfall, the transplanting is carried out during March–April to obtain flowers from August to October. However, in controlled greenhouses, there is no problem as to when the carnations should be transplanted.

Spacing

Depending upon the type of pinching and cultivar, different densities are adopted. It would be better to

NOTES

adopt 20 × 15 cm (33 plants/m^2) spacing for standards and 20 × 20 cm (25 plants/m^2) for sprays. For better aeration and convenience, the latter spacing is more practical where some 1,87,000 plants are accommodated per hectare. However, 30 × 30 cm spacing is considered the best because of proper air circulation where some 83,110 plants/ha can be accommodated.

Staking or support

With the help of fixed frames on either end of the beds, nylon nets of 10 × 10 cm, 12.5 × 12.5 cm or 15 × 15 cm square are placed on beds before taking up planting. To support the stems, the nets are raised upto 15 cm height of plants after the plants have attained 20 cm height.

Manure and fertilisers

A sizeable description about the application of fertilisers is given under 'Bed preparation', however in addition to that, six quintals of calcium ammonium nitrate should be given one month after transplanting by mixing thoroughly in the field. Leaf sampling and testing for further use of fertilisers and other elements such as Fe, Zn, Cu, Mn, Mo, and B can be worked out so that these are applied as per requirement as foliar sprays. A basal dose of NPK at the rate of 20:20:10 g/m^2 is applied three weeks after planting. Fertigation is done with N at 100 ppm and K at 140 ppm twice in a week along with other nutrients such as Ca, Mg, Fe, B, Mn, Cu, and Zn. Excess of potassium causes magnesium and boron deficiency. It may cause excessive calyx splitting and abnormal opening of flower buds.

Irrigation

Watering is carried out once immediately after planting and then through drip system, because the use of sprinkler is prohibited in carnation planting for the fear of spread of disease. Drip irrigation is the best option for maximum saving and need-based application. After the establishment of plants, they must be regularly watered during warm sunny days.

Weed control

Whether it is a greenhouse or an open field cultivation, the weeding in carnation is carried out only manually through the antiquated tool khurpi or khilni. No weed should be allowed to grow and flourish as it will deteriorate the crop production.

Pinching or stopping

Pinching is a practice for quality carnation production. First pinching in carnation, preferably below the sixth node, is carried out about one month after planting, wherein, leaving five to six nodes on the plant, the tips of apical shoots are removed, and this is technically known as first or single pinch. In this case, flowering occurs earlier and at one time. Plants pinched above the sixth node produce flowers on smaller axillary shoots, therefore, pinching below the sixth node is recommended. However, pinching above the sixth node has another advantage as the plants produce six well-developed lateral shoots. This is particularly applicable in standard carnations for harvesting higher percentage of quality flowers. Pinch and a half (second pinch) is a usual single pinching in carnation and then after 30–45 days when the laterals have attained about 10 cm length, half of the longer laterals leaving about two to four pairs of leaves (one to two nodes) are again pinched so that two–four shoots come out again. This way, two to three flowers are obtained early in the first flush and six to eight in the later flush. This type of pinching does not have any peak time for flowering and the time is drastically reduced in obtaining the first blooms. In double pinch, first the single pinching of the main shoot is done as in single pinch, then after about five to six weeks of first pinching, second pinching of all the laterals at two to three nodes is done. This way generally 8–10 shoots are retained and the operation is carried out to delay the flowering period.

De-shooting

After pinching, many side shoots (offsets) start appearing and when these attain some 3–5 cm length, these are

NOTES

removed in standard carnations leaving 3–5 shoots per plant, but in case of spray cultivars 6–10 such shoots are retained.

Disbudding

This operation is usually carried out in standard carnations where all the lateral buds below the terminal one are removed when they are 5–10 mm in diameter. The lateral buds down to about six nodes from the terminal floral bud are removed to divert the entire energy towards development of the main terminal bud. In case of spray cultivars, number of lateral buds can be increased by removing main terminal bud from the plants.

Use of growth regulators

Spray of 50 ppm benzyladenine (BA) at monthly intervals increases the yield of cuttings. Long-stemmed blooms with early flowering can be obtained by spraying 100 ppm GA_3 twice — once at first pinch, and second, when axillary shoots are about 10 cm long. Spray of 300 ppm mepiquat chloride — first, when axillary shoots are about 10 cm and the second, at floral bud initiation, produces healthy stems, and reduces calyx splitting.

Harvesting, yield and post harvest

In standard carnations, the flowers are harvested at paint-brush stage, the stage when elongation outside the calyx starts or when bud diameter is 1.5–2.0 cm; while in sprays when each stem has two opened flowers and other buds showing colour. The harvesting of flowers is carried out early in the morning and the cut ends are placed in a bucket containing palatable water. While harvesting the flower stems, some 3–4 nodes should be left below the stem on the mother plant for growth of the next season's crop. Crop is retained at least for two years for a good harvest.

Grading

The harvested flowers are graded on the basis of flower quality and stem lengths:
Blue/Fancy (A grade): with 60–70 cm stem length
Red/Standard (B grade): with 50–60 cm stem length
Green/Short (C grade): with 40–50 cm stem length

The cut flower yield is 150–400 per square metre area. Yield in the open field varies from 150 to 200 stems and in the greenhouse it is 300 to 400 stems/m^2, however, in the second year the yield jumps to its one and half times.

Post harvest

Carnation flowers are very sensitive to ethylene, that's why just after harvesting, these should be kept or pulsed in a solution containing 10% sucrose + 1 mm STS (silver thiosulphate) for up to 10 hours before transportation to sustain their proper life. After pulsing, the flowers can be stored in water with a nutritive solution at 2°–4°C and 95% RH so that sleepiness can be avoided to occur. Ordinarily the cut flower life of carnation is six days which can be extended up to 22 days by the addition of silver ions in the water electrolytically.

Bunches of 25 flowers each are packed in the insulated corrugated cardboard box of the dimension 122 × 50 × 30 cm, which accommodates some 800 flower stems putting cut ends in the centre and the flowers at both the ends of the boxes and in between the bundles, the newspapers are layered all around the flowers. These are transported at 2°–4°C temperature in refrigerated van.

Pests

Gram pod borer/cotton budworm *(Helicoverpa armigera)*

Its larvae are highly destructive to every part of the plant as these feed voraciously and damage the whole plant. Methyl parathion spraying at 0.2% twice fortnightly is very effective for controlling this pest.

Carnation tortrix moth *(Tortrix pronubana)*

Its larvae fasten some of the leaves together with silken threads and feed voraciously beneath this shelter, on leaves, stems, growing points and bore the floral buds, especially during summer months. Fortnightly spraying of the plants with sevin at 0.15% + kelthane at 0.2% from July to September will keep this pest at bay.

Armyworm *(Spodoptera exigua)*

Its larvae are highly destructive to the basal part of the stem. These are controlled by mixing furadan granules in the soil at the time of soil preparation.

Aphids *(Myzus persicae)*

The nymphs and adults cluster towards the tip of the shoots and other tender parts, and remain there sucking the sap. Apart from transmitting viral infections to other plants, their infestation invites ants and sooty mould. Malathion at 0.2% or demeton methyl at 0.25% spraying will control this pest.

Thrips *(Frankliniella tritici, F. occidentalis, Thrips tabaci)*

The nymphs and adults feed voraciously on leaves and flowers by rasping their sap. Their infestation causes patches with black specks, crinkling and yellowing of leaves and streaking of flowers. These continue feeding on the undersurface of leaves during daytime, especially in clear weather. Controlling aphids will control these pests also.

Carnation fly *(Delia brunnescens, Hylemya brunnescens)*

Its maggots tunnel into the leaves and stems of carnation which results into wilting and death of the plant. Leaf beetle (*Aulacophora nigripennis*) has also been found infesting carnation leaves. At initial stage of infestation, these may be controlled through fortnightly spraying with 0.2% rogor thrice.

Red spider mite *(Tetranychus urticae)*

It is the most serious pest of carnation where nymphs and adults both stick to the underside of the leaves, and continue sucking the plant sap so the leaves become pale-yellow with dusty coating cum fine webbing. Their infestation causes the plants to stunt and the flower quality becomes very poor. Spraying dicofol (0.2%) fortnightly is effective in controlling this pest.

Nematodes *(Pratylenchus curvitatus, Helicotylenchus varicaudatus, Meloidogyne incognita)*

These have been found infesting carnation roots causing root galling, root injury, plant stunting, and reduction

in the number of flowers. Before planting, the soil should be sterilised and at the time of soil preparation, Furadan 3G at 25–40 kg/ha should be mixed in the soil just before planting and watered just after planting. This will kill the whole nematode population present in the field. The cuttings should be taken from a healthy stock.

Diseases

Fusarium wilt *(Fusarium oxysporum f. sp. dianthi, F. roseum var. cerealis)*

This is the most serious problem of carnation during warm and humid weather conditions where the leaves of the affected plants become yellow and drop, the stems become soft and collapse with ultimate death of the plants. *F. roseum var. cerealis* causes rotting of all the stem parts. Fusarium culmorum infects the stems at the soil line and a little above, and the rotting starts from the surface tissues and extends to the inner side, ultimately causing the death of the entire plant. *Fusarium tricinctum f. poae* is carried onto the carnation from grasses through a mite *Siteroptes graminum* which carries it deeper into the flower centre so it is controlled by controlling the vector through kelthane at 0.2% concentration. Before planting, the soil should be sterilised through solarization. Drenching of soil around the plant's base with bavistin (0.15%) is quite effective. Spraying the plants with mancozeb (0.1%) + bavistin (0.1%) also proves very effective in keeping these diseases under control.

Rhizoctonia stem rot *(Rhizoctonia solani)*

It is a soil-borne disease, therefore it is transmitted through infected soil. This affects the plants at the soil level and within a week of its infection, the plants die. Drenching the infected plants either with bavistin (0.2%) or thiram (0.2%) can be effective in controlling this disease.

Alternaria leaf spot and blight *(Alternaria dianthi)*

It appears as spots on stems and leaves so the leaves die prematurely. Bud rot is caused due to the infection of A. *dianthicola* during cool and humid weathers. Leafspot

is caused by *Septoria dianthi* whose infection on leaves causes light brown circular spots with a purplish-brown border on the leaves, and sometimes even on the stems. Here, the centre of the spots bear minute black specks. These spots expand and coalesce to form larger blots, sometimes with shot holes. To prevent the spread of *Septoria* to other leaves and plants, wetting of the plants should be avoided, and infected leaves should be removed. Chemical controls are similar to that of *Alternaria*. To prevent *Alternaria* infection, the soil should be sterilised, the cuttings used should be collected from a healthy stock, dipped in 0.2% mancozeb for 30 minutes and sprayed fortnightly with 0.2% mancozeb or 0.3% Blitox.

Rust *(Uromyces caryophyllinus)*

It appears on carnation leaves and stems as chocolate-brown patches, causing early defoliation and poorly grown plants with stunting and curled leaves. The disease is favoured by highly humid condition. It is controlled through spraying with 0.15 Plantvax (oxycarboxin) + 0.2% mancozeb.

Flower bud diseases

These are caused due to the infection of *Alternaria dianthicola, Fusarium tricinctum f. poae, Botrytis cinerea*, and *Pleospora herbarum* (the former two have been described earlier). *Pleospora herbarum* causes calyx rot in carnation but its control in the open is very difficult, however, in the greenhouse, spraying zineb and maneb at 0.2% may control this pathogen. *Botrytis cinerea* causes graymould (*Botrytis blight*) in carnation. This is a very serious problem when the weather is humid and cool. This pathogen causes rotting of stored cuttings and water-soaked lesions on the flowers in the field during the rains, and in storage where temperature is quite low and humidity is very high. The disease intensity can be reduced by reduction of humidity levels both in the greenhouse and storage. Captan, zineb, chlorothalonil, or iprodione at 0.2% spraying will control this problem.

Bacterial leaf spot *(Pseudomonas woodsii)*

It is observed on the carnation leaves in the form of elongated brown spots, where in severe cases the plants get killed. However, the infected leaves should be removed

and burnt and the plants should be sprayed with Bordeaux mixture or copper oxychloride in the end of summer (by the start of autumn) and again in mid-autumn.

Viruses

Carnations are attacked by streak, mosaic, mottle, vein mottle, ring spot, and etched ring viruses by which flower quality and yield get reduced drastically. Vein mottle, mottle, carnation yellow necrotic fleck virus, carnation etched ring virus and carnation latent virus are carried by aphids while the ring spot and mottle spread through harvesting tools and handling. The vector for streak virus is not known. Mottle virus causes leaf mottling and colour breaking. Through shoot culture, the virus may be avoided. To get rid of viruses, the best way is to uproot and destroy such plants along with timely control of insects.

Physiological disorder

Calyx splitting

It is due to nutritional imbalance, erratic irrigation, genetic and environmental factors, and cultural practices. It occurs mostly because of the excessive number of petals in the buds coupled with temperature being lower than 10°C at the time of bud formation and development. Low nitrogen, high ammonical nitrogen or low boron levels also contribute towards calyx splitting. When calyx is unable to bear the pressure being generated due to sequential growth of the petals, calyx ruptures completely or into two halves, and such flowers are not acceptable in the market. It is suggested that a rubber band be placed on the bud at the time of maximum growth when mouth just starts opening and at the portion having maximum diameter. Sometimes calyx splitting occurs at the bud formation stage, when there is water scarcity in the soil, followed by sudden irrigation. Application of nitrogen to a certain limit controls the splitting, however, over-fertilising with nitrogen may also cause splitting. High day-temperature and low night-temperature may help checking the splitting.

Curly tip

It is distortion and curling of the growing tips, young shoots failing to separate and continuation of growth occurs in a characteristic curvature which is probably due to low light and low temperature conditions prevailing for long, and this may further aggravate due to nitrogen deficiency.

Practical Exercise

Activity 1

Demonstrate the cutting of carnation.

Procedure

- Carnation is multiplied through terminal cuttings.
- The mother plants from which cuttings are to be taken should be covered from November to February.
- Prepare 10–15 cm long cuttings with 4–5 pairs of leaves and at least three nodes.
- Remove 1–2 pair of lower leaves.
- Prepared cuttings should be treated for 12 seconds with NAA 500 ppm.
- Drench the rooting medium with 0.2% solution of Bavistin or captan.
- Plant the prepared cutting in a sand bed or in cocopeat in mist chamber.

Check Your Progress

A. Fill in the Blanks

1. All the lateral buds below the terminal one are removed when they are 5–10 mm in diameter in _____ method.
2. A practice for quality carnation production is _____.
3. Carnation is propagated by _____.
4. Carnation can be planted at _____.
5. Terminal cuttings of _____ length with at least three nodes are used for propagation.

B. Multiple Choice Questions

1. Carnation yields _____.
   (a) 150–400 cut flowers/m^2
   (b) 300–500 cut flowers/m^2
   (c) 500–600 cut flowers/m^2
   (d) 600–700 cut flowers/m^2

2. Carnation blue or Fancy (A) grade has _____ stem length.
   (a) 90–100 cm
   (b) 60–70 cm
   (c) 100–120 cm
   (d) 120–150 cm
3. Red or Standard (B) grade carnation flowers have _____ stem length.
   (a) 30–40 cm
   (b) 40–50 cm
   (c) 50–60 cm
   (d) 60–70 cm
4. The Green or Short (C) grade flowers of carnation have _____ stem length.
   (a) 30–40 cm
   (b) 40–50 cm
   (c) 50–60 cm
   (d) 60–70 cm

C. Subjective Questions

1. How can carnation be propagated by cutting?

   _____
   _____
   _____

2. What is pinching in carnation?

   _____
   _____
   _____

3. Give the causes and remedy for calyx splitting in carnation.

   _____
   _____
   _____

4. Describe the methods of harvesting in carnation.

   _____
   _____
   _____

5. What are the physiological disorders of carnation?

   _____
   _____
   _____

6. How is post harvest care taken with harvested flowers?

   _____
   _____
   _____

NOTES

7. Write about the grading of carnation flowers.

_____

_____

_____

C. Match the Columns

A	B
1. Calyx splitting	(a) *Pseudomonas woodsii*
2. Curly tip	(b) *Alternaria dianthicola*
3. Bacterial leaf spot	(c) Nutritional imbalance
4. Flower bud diseases	(d) *Tortrix pronubata*
5. Carnation tortrix moth	(e) Low light and low temperature

Session 6: Cultivation Technique of Gerbera

Gerbera: *(Gerbera jamesonii)*

Family: Asteraceae

Gerbera (Barberton daisy, Transvaal daisy, African daisy and Hilton daisy) is an important cut flower crop, even used for bedding and border planting, and is grown throughout the world. It is native to the Republic of South Africa (Fig. 1.13).

Fig. 1.13: Gerbera

Varieties

Aalsmeera (orange), Aida (orange), Alp (white), Ansofie (off-white), Appelbloesem (pink), Aruba (yellow), Baron

(red), Blush (red), Calcutta Pink (pink), Calcutta Red (red), Calcutta White (white), Calcutta Yellow (yellow), Casava (red), Cornice (orangish-yellow, disc orange, centre black), Cream Clementine (cream), Crossroad (yellow, centre red), Davis Memory (light mauve), Delphi (white), Dino (semi-double, yellow), Dusty (red), Faith (orange), Fiona (light pink), Flamingo (pale-rose), Foske (orangish-yellow, disc small and orange), Fredaisy (pink), Fredeking (yellow), Fredorella (red), Fuego (red), General Kaiser (mauvish-orange), Goldspot (orangish-yellow), Goliath (orange, centre yellow), Gracia (large, violet-red), Greenish Yellow, Gucci (pure yellow), Kalimpong Red, Kalimpong Yellow, Labalgo (lilac), Laurentius (yellow), Lilabella (purple-red), Magnum (pink), Maron Clementine (orange), Nevada (light yellow), Ornella (red), Pink Elegance (deep pink), President (red), Princess (yellow), Rosabella (pinkish-mauve), Rosalin (soft mauve), Ruby Red (red), Sangria (red), Sundance (yellow, margins intense), Sunset (red), Symphonie (white), Terramor (light red), Terraqueen (pink), Tropic Blend (yellow), Uranus (yellow), Valentine (pink), Venturi (red), Vesta (red), Vino (red), Whitsun (white), etc.

Climate

In gerbera, the optimum temperature should be 8°–23°C and light 450–600 foot-candle (fc) for vigorous growth and quality cum quantity flower production. Short days along with high light intensity is excellent for flower production, however, the influence of cultivar dominates it. Warmer temperature encourages growth while the cold temperature slows it down. Gerbera plants are slightly photoperiodic but highly responsive to high light intensity and its duration. Short days speed up flowering while long days delay it. Optimum relative humidity for growing it should be 70%.

Soil

Gerbera is not very particular about the soil types, though the soil and irrigation water EC should be below 1, however, the soil should be quite deep (>50 cm), porous, well-drained, rich in organic matter including nitrate with a soil pH of 5.5–7.2, and have good water-

holding capacity. Higher acidity in soil hampers the absorption of Mn and Fe while lower acidity causes the worst soil structure. Slightly calcareous soil with proper soil characteristics is excellent for gerbera cultivation, however, the excess of lime or excess moisture at the roots causes chlorosis where leaves show yellowing. Peat soils are quite unsatisfactory, especially where the water table is high. An ideal soil mixture for gerbera cultivation would be 1 part coarse sand + 1 part fibrous loam + ½ part peat + ½ part well-decomposed leafsoil + ¼ part well-rotten manure. Before planting gerbera, the soil is either solarized or sterilised with 2% formalin as a precautionary measure against the infection of soil-borne pathogens such as *Fusarium, Phytophthora, Pythium, Rhizoctonia*, etc.

Propagation

Seed propagation is meant only to evolve new varieties as normally through seeds the plants are not true to the type, and in most cases, the improved varieties do not set seeds.

Gerbera is propagated vegetatively through the division of clumps and cuttings, *vis-à-vis* micropropagation. It is planted in early September on the hills and subtropical weather or climate in June – July in the plains. The clumps are lifted and divided into smallest units, having central growing point intact, the leaves are trimmed and the whole clump is treated with 0.2% captan. Divisions of clump are then planted at a filtered place having 18°–20°C temperature and more than 80% RH, in the sterilised medium by having the central growing point perfectly exposed, followed by watering. These take 2–3 weeks for establishment and when flowers start appearing the first flowers should be nipped. In suckers planted in September, flowering starts from February.

Growing of plants at 25–30°C temperature with more than 80% RH in a nutrient-rich soil encourages the formation of more side shoots in the axils of leaves which are detached similar to that of clump-division and planted in rooting media where these become ready for transplanting in 2–3 months.

It is now a common trend in the country to multiply the planting stalk of the elite cultivars through tissue culture for obtaining uniform and disease-free material. Generally, MS medium supplemented with various growth substances is used with gerbera explants such as shoot tips, floral buds, capitulum, leaves, midribs, petioles, etc.

Bed preparation

For planting, soil should be made fully pulverised through deep ploughing, rootstocks of the perennial weeds along with other hard foreign materials such as pieces of wood, stones, bricks, and plastic shreds taken out and then properly levelled. It would be wise to disinfect the soil before planting, to avoid the menace of Phytophthora and other root rot fungi. Soil may be solarised by covering it with black polythene film for 6–8 weeks so that solar heat is generated, and all the spores of harmful fungi are killed.

Usually, gerberas are grown on 15–20 cm raised beds for better drainage. Bed width may be adjusted at 1.2–1.6 m at any length as per the convenience. Between two beds, there should be clearance of 40 cm to facilitate walking, irrigation, and cultural operations in the field.

Planting

In seedlings, the vegetative shoot is formed terminating into a flower, followed by a second flower, then a third, and so on. Before the first flower appearance, some 2–8 leaves are formed on the plant. Subsequently, for production of flowers, every time new lateral vegetative shoots emerge with almost the same number of leaves, and these vegetative buds are known as crown, and so in a course of time, the plant becomes quite leafy due to primary rootstock, secondary, and so on. The crown should be well above the surface of the soil. In case of annual cropping, the spacing should be close while for perennial cropping, it should be wide. Spacing in the beds or in the large pots for the plants being grown for cut flower production is recommended as 33 × 33 cm to 38 × 38 cm.

Planting time

In India, the proper planting time for most of the tropical and sub-tropical regions should be October (open or in greenhouse), while in Kerala, it is June. Plant density of 7.5 plants/m^2 is thought to be standard. Planting on the hills can be carried out in February–March. In case of gerbera, no pinching is required, however, the very first flower may be nipped to promote vegetative growth and uniformity in flowering.

Manures and Fertilisers

Gerbera is heavy feeder, so frequent application of nutrients at regular intervals is useful for optimum growth and flowering. Farmyard manure at 750 quintals per hectare in fairly light sandy soil at the time of preparation should be incorporated and thoroughly mixed, and in the second year, it should be incorporated with peat as a substitute for manure, provided the pH through liming is adjusted at 6.0–7.5. Growing in peat with ammonium nitrate plus superphosphate plus potassium sulphate at 4 g/l is quite beneficial in producing quality blooms. Excess of nitrogen reduces yield and vase life, and deficiency causes yellowing of old leaves as this translocates in the new leaves upward. Underside of the veins in older leaves show brown discolouration due to phosphorus deficiency, marginal necrosis of old leaves occurs due to potassium deficiency, and intense yellowing of new leaves occurs in case of Ca deficiency, Mg and Fe requirement is more in this crop and Mg deficiency is characterised as thick and crispy interveinal chlorosis on older leaves.

Irrigation

Over-watering in gerberas at any stage of their growth and development is not advisable. The plants should be allowed to get dried slightly between two irrigations which will cause plants to retard naturally without any use of growth retardant on potted plants. When watering, these should be sufficiently watered, at least 5 cm flooding throughout so that soil becomes moderately moist to a depth of at least 10 cm. Water requirement of

the full-grown gerbera plant is from 500–700 ml per day depending upon the prevailing weather conditions and growth stage of the crop. Sub-surface drip irrigation is the best for maximising flower production. The irrigation should be based on the soil type, the weather condition, and the crop stage. First, water is given immediately after transplanting. Irrigation water should be of good quality having proper EC and pH.

Harvesting and yield

First flowers appear after 50–70 days of planting. While the outer two whorls of disc florets are falling straight on the flowerhead showing pollen grains in case of singles, and the disc flowers being fully developed in doubles, these are harvested during cool hours of the day by pulling (not cutting) near the base of stalk. About 150–250 flowers are harvested per square metre annually. Though there is a great difference in the vase life of various cultivars but normally freshly harvested gerbera stems last 2–3 weeks.

The cut flowers are pulsed with 1000 ppm silver nitrate, 600 ppm sodium hypochlorite, 6% sucrose, and 0.1% Tween-20 surfactant for 10 minutes for reducing bacterial stem blockage and to prolong vase life. Immersing the gerbera cut ends for 24 hours in a 200 mg 8-HQS, 50 mg $AgNO_3$, and 5% sucrose in one litre of water prolongs the life by 4–5 days.

The flowers are packed in insulated boxes for transportation from one place to another, but in Holland, plastic-coated metal grids of 50 × 75 cm with mesh size of 2 × 2 cm are commonly used by the seller for packing gerbera flowers. The flower heads are supported by the grids or mini sleeves which are suspended above a plastic tray measuring 48 × 70 × 30 cm, at a height which can be adjusted as per the length of the floral stalk so that cut ends are immersed in water to a 15 cm depth in the tray. Individual flowers are now a days packed in specially prepared transparent polythene bags but with cut ends inserted into air-tight plastic tube filled with water or vase-solution. Locally, these are packed in bunches of 10–12 with their cut ends placed in water or vase solution. The stem length of gerbera should not be

less than 40 cm, should be straight, firm and the flower diameter not less than 7 cm.

After receiving the consignments, the cut stems require to be rehydrated immediately with 43°C warm water. Solution of 25 ppm silver nitrate at 3.5 pH should be used as a holding solution and dipping the flower heads in 0.1 mM benzyladenine (BA) delays the senescence and maintains the flower weight. Gerbera cut flowers respond well to re-cutting of cut ends before placing in preservative solution or until marketing. Shortage of water as a result of vessel blockage or microbial growth may cause flower drooping. Its stalk being hollow, sometimes due to filling of air inside, water absorption is held up so pricking of the stalk 10 cm below the flowerhead will facilitate escape of the air, *vis-a-vis* help in the absorption of water.

Insect-pests

White flies *(Trialeurodes vaporariorum)*

When greenhouse weather is hot and dry, gerbera may be attacked with tiny white flies (1.5 mm long). After hatching from the eggs, the new crawlers start moving from leaf to leaf and then start sucking the sap from the young leaves from where these do not move until their maturity, then moulting into nymphs of yellow colour with red eyes and then into pupae, and finally, becoming whitish-yellow adults. Its infection causes chlorosis, yellowing of leaves, premature leaf defoliation cum bud shedding, and gradual drying of the plants, and overall infested plants become aesthetically unappealing. Spraying the insecticides such as Confidor (Imidacloprid) at 0.005%; Astra, Lanate (Methomyl) or Pride (Acetamiprid) at 0.004%; and Neemazol, Rogor (Dimethoate) or Malathion at 0.02% continuously thrice at 5–7 days will control all the stages of this pest.

Leaf miners *(Liriomyza trifolii, L. huidobrensis)*

The yellowish-brown larvae feed on the plants by irregularly tunneling the young leaves, and their severe infestation causes drying and drooping of the leaves. Neem cake extract is highly effective which may be used

regularly. Twice spraying of Imidacloprid, pyrazophos, or Esfenvalerate at fortnight intervals will control this pest. Vertimec (Abamectin) at 0.005%; Chlorpyriphos or Dichlorovos at 0.01%; Acephate or Methomyl at 0.015%; or Dimethoate at 0.1% spraying will control this pest.

Aphids *(bean aphid, Aphis fabae;* green peach aphid, *Myzus persicae)*

The nymphs and adults of aphids cluster on new growth and around tender plant parts rasping their sap and distorting them. These can be controlled through fumigation with Sulfotep smoke cartridges at 200 m^3 or Primicarb smoke candles at 700 m^3, and chemical control through spraying with 0.01% Ambush, 0.02% Malathion, 0.1% Dichlorvos, Methomyl or Oxamyl, 0.04% Decamethrin or Cypermethrin. Spraying water with jet nozzle or spraying of the tobacco decoction will also control these pests.

Mites *(Hemitarsonemus latus, Steneotarsonemus pallidus)*

Former mite feeds even on gerbera roots and the next one on the leaves and flowers, spin the webs and cause crooked and deformed flowers. Sulphur dusting of plants before flowering and Mitac, Torque, and Rospin application to the flowering plants will control these mites.

Caterpillars *(Helicoverpa armigera)*

These being polyphagus, feed on every part of the plant. *Bacillus thuringiensis* based parasites are very effective in keeping such insects under check.

Root-knot nematode *(Meloidogyne incognita)*

It causes root-galling so root and shoot growth is restricted and foliage becomes yellow. Organophosphate chemicals mixed in the soil will control this pest. Neem cake 30–50 g/plant, Carbofuran (Furadan) 10 g/plant or Diazinon (Suzon) 0.015% drenching will kill the nematodes to a great extent.

Slugs and snails

These occur in high humid areas having diffused or no light and where temperature is below 21°C. During

daytime, these hide themselves below the debris but become active during the night hours when these feed on foliage, new shoots, and flowers. Proper sanitation will destroy their hiding places. These can be trapped by spreading vegetable refuse. Introducing finely ground lime in dry soil and during dry period, and copper sulphate barriers will kill these pests while crossing the line.

Diseases

Crown/foot/rootrot or wilt *(Phytophthora cryptogea)*

It is a soil borne disease. Due to its infection, the plant roots and stalk bases become black-brown, followed by rotting. Its infection causes crown rotting and ultimate death of the infected plant. *Fusarium oxysporum* also causes foot rot with almost the same symptoms as that of *Phytophthora* but on cutting, vascular system of such plants shows blackening. Top-dressing of nutrients such as ferrous sulphate, Zn-EDTA, or zinc sulphate and calcium nitrate suppress the incidence of *Phytophthora* foot rot. Soil sterilisation with Vapam at 100 ml/m^2 keeps this problem under check, and warming of the soil at 26°C also reduces incidence of this disease. Soil sterilisation together with regular application of fungicides such as copper oxychloride in the soil will control even the root rot caused by soil-borne pathogens such as *Pythium irregulare, P. ultimum, Sclerotium rolfsii, S. sclerotiorum,* and *Rhizoctonia solani.*

Pythium

Infection stunts the plants together with peeling of the root skins while *Sclerotium* causes aerial rotting, and these become very serious at 30–34°C temperature range. *Sclerotium* infection appears first as water-soaked lesions on collar and other parts touching the soil, and then afterwards, the plants turn yellow, then brown to black and then die. Methyl bromide or Metam at half doses under plastic is very effective though its full dose causes phytotoxicity. Prothiocarb at 0.15% on young infected plants or Furadaxyl at 2 g/l is quite effective in controlling these pathogens.

Rhizoctonia solani

This causes plant stunting and ultimate death of the plant. Soil sterilisation and drenching with 0.4% copper oxychloride or 0.2% Dithane M-45 controls this disease.

Powdery mildew

It is caused by *Erysiphe cichoracearum, E. sclerotiorum,* and *Oidium erysiphoides f. sp. gerberae*. Due to their infection, white powdery coating on gerbera foliage and floral stalks occurs. Spraying of karathane or wettable sulphur is found effective against *E. cichoracearum,* while *Oidium erysiphoides* f. sp. *gerberae* is brought under control by removing the old leaves, allowing proper ventilation, by reducing relative humidity and spraying 0.1% benomyl in the greenhouse. Spraying of dinitro capryl phenyl crotonate (Mildex) at 0.25% + a wetting agent controls the disease without any plant injury.

Blight (Grey mould)

This occurs as plants are infected with *Botrytis cinerea* due to deep planting, poor aeration cum ventilation and poor drainage in the greenhouses by which small black spots on ray florets appear. In the morning, when atmospheric humidity is more than 90% for more than two hours, grey spots on the flower petals start developing. It also kills the young growing tissues, and its infection also causes damping off in seedlings. Benlate at 0.1%, Dithane M-45 or Z-78 at 0.2%, or Thiram at 0.1% weekly spraying may control this problem. Sprinkler or overhead irrigation should be avoided.

Leaf spot *(Alternaria brassiciola, Phyllosticta gerbericola* and *Cercospora gerberae)*

These pathogens cause various kinds of leaf spot symptoms on gerbera leaves. Such problems may be controlled through spraying with 0.2% Dithane M-45 or Z-78. Sometimes, *Verticillium dahliae* causes severe stunting and slow wilting of plants, and this should be controlled through soil sterilisation.

Viruses

So far recorded, viruses on gerbera crop are CMV, 'gerbera ilar virus' (GIV), 'gerbera mosaic virus' (GMV), TRV, and TSWV which spread through aphids, thrips, and nematodes. CMV causes leaf mottling and distortion of colour with broken streaks on flowers, stalks, and leaves. GIV retards the growth with chlorosis. GMV is transmitted through grafting and causes mottling in the plants. TRV transmitted through Trichodorus nematodes expresses yellow or black annulated ring spots on the leaves. The nematodes are controlled through soil steaming before crop planting. TSWV reduces plant vigour so the flower quality becomes poor. One can get rid of viruses through sanitation, immediate destroying of the infected plants, use of virus-free material, soil steaming to kill nematode vectors, and management of virus vectors.

Practical Exercise

Activity 1

Collection of various disease samples of gerbera plant

Material required

Herbarium, sticking tape, coloured pencil, pen, etc.

Procedure

- Visit a nearby greenhouse or field planted with the gerbera plant.
- Observe the plants for symptoms of various diseases.
- Pluck the leaves showing clear symptoms.
- Paste the dry leaves on the herbarium sheet.
- Write down the information of the disease symptoms shown.
- Information to be written includes —
  - Name of the disease
  - Causal organism
  - Control measures
  - Place of collection
  - Date of collection

Check Your Progress

A. Fill in the Blanks

1. Gerbera is a native of _____.
2. Gerbera can be propagated vegetatively through _____ and _____.
3. Planting time of gerbera in most of the tropical and sub-tropical regions is _____.
4. In gerbera first flower appears after _____ days of planting.
5. About _____ flowers of gerbera are harvested per square metre annually.

B. Multiple Choice Questions

1. Farmyard manure at _____ per hectare in fairly light sandy soil at the time of preparation should be incorporated.
   (a) 750 quintals
   (b) 1000 quintals
   (c) 1500 quintals
   (d) 2000 quintals
2. Water requirement of the full-grown gerbera plant is from _____ per day.
   (a) 400–500 ml
   (b) 450–600 ml
   (c) 550–760 ml
   (d) 500–700 ml
3. Gerberas are grown on _____ cm raised beds for better drainage.
   (a) 10 to 15
   (b) 12 to 22
   (c) 15 to 20
   (d) 15 to 25

C. Subjective Questions

1. Write the procedure of commercial propagation of Gerbera.

   _____

   _____

   _____

2. How is the bed prepared for Gerbera planting?

   _____

   _____

   _____

NOTES

3. What is the bent neck in Gerbera?

_____

_____

_____

D. Match the Columns

A	B
1. GIV	(a) 500–700ml/day
2. Gerbera planting	(b) Stunted plants and peeling of root skin
3. Pythium	(c) October
4. Water requirement	(d) Gerberailar virus

Unit 2

Cultivation of Commercial Flower Crops–II

The aesthetic, social, and economic aspects of flowers, which got due attention in the second half of 20th century, directly influence humankind and human environment.

The offering and exchange of flowers on all social occasions of joy and sorrow, for adorning hair by womenfolk in different parts of the country, for home decoration and worshipping, is now becoming a standard practice for Indian society. Cultivation of flowers plays an important role in environmental planning of urban and rural areas for overcoming pollution, social and rural forestry, wasteland development, as well as outdoor and indoor landscaping. Its cultivation provides higher income, even from comparatively smaller areas with higher profitability than other crops. However, the advanced floriculture technology is capital intensive in view of the high cost of protected structures. Its cultivation generates gainful employment for women and other unemployed youths in sub-urban and rural areas.

On commercial level, in the Indian floriculture sector, the cultivation of various flowers has emerged as a profitable agribusiness in both domestic and export market. Apart from fresh flowers and live plants, the floriculture industry deals even with dry flowers and

value-added products such as bouquets, floral baskets, flower arrangement, garlands, and pot-pourris.

Loose flowers, *viz.*, rose, marigold, annual chrysanthemum, gaillardia, jasmine, barleria, crossandra, etc., have occupied more than 60 per cent of the area of flower cultivation. Selection of flower crops and its variety for commercial cultivation should be proper as per the soil, climatic condition, available resources, market demand cum consumer choice, and availability. Crop growth, flower yield, and quality are directly proportionate to the good management practices. Good agricultural practices (GAP), *viz.*, precise land preparation, raising of seedlings in protected condition, planting on raised and 'broad bed and furrow system', mulching, using of drip irrigation (per drop more crop), fertigation, soil-test-based fertiliser application, integrated pest management, and proper post harvest management ensure quality produce. These practices also reduce the cost of flower cultivation and maximise the profit of cultivators.

Session 1: Cultivation of Rose

Botanical name: *Rosa hybrida*

Family: Rosaceae

Roses are older than the human race on this earth and native to the temperate zone of the northern hemisphere, with a few species occurring even in the sub-temperate, sub-tropical, and tropical areas. It has hardly 120 species, out of which some 11 species are native to India. It is found in various sizes, shapes, and colours, and is globally known as 'Queen of the Flowers'. There are many species whose flowers are mildly to highly fragrant. It bears the most beautiful flowers, used in bouquets, as cut flowers, loose flowers and for preparing 'rose scents'. It can be grown as a pot plant, hedge, specimen plant, for making standards and sub-standards, as shrubs and climbers. Flowers are also used for the extraction of essential oil, for preparing *pankhuri* (petals), and for making conserves, rose vinegar, rose petal wine, jam, jellies, syrup, pot-pourri,

rose water, and *gulkand*. Its hips contain three times more ascorbic acid than that in oranges and about seven times more than tomatoes (Fig. 2.1).

Fig. 2.1: Rose

Major Rose Types

Modern roses

They have a complicated classification. Many of the modern roses have old garden roses in their ancestry with too much variation in their forms, and the classification is also based on the growth and flowering characteristics such as large-flowered bush (Hybrid Tea); cluster-flowered bush (Floribunda); dwarf cluster-flowered bush (Patio rose); miniature; ground-cover recurrent and non-recurrent; climbers and ramblers; and shrubs but commercially only four groups are recognised, that is, (i) cut flowers, (ii) miniature potted flowering holiday plants grown from stem cuttings, (iii) flowering pot-plants produced from bare-root plants, and (iv) potted garden plants produced from bare-root plants.

Hybrid Tea (HT)

It is the successor to the Hybrid Perpetual which possesses free-blooming habit. It has a long flowering season from June to October in the temperate regions and from December to April in the plains of tropical

and subtropical regions. It is the most popular type of usually vigorous, 75–180 cm tall, long, and strong-stemmed and solitary but nearly always double-flowered roses. It is most suitable for growing in greenhouses as cut flowers. Hybrid tea flowers almost continuously throughout the season, bearing large long-pointed buds having well-formed flowers which are attractive with almost all the colours, symmetrical, and mostly fragrant. They are susceptible to cool temperature so they require winter protection in areas experiencing severe cold during winter. The most popular varieties are Aalsmeer Gold, Abhisarika, Ace of Hearts, Alinka, Ambiance, Angelique, Belami, Blue Moon, Bulls Red, Cabaret, Calico, Century Two, Dr. Bharat Ram, Double Delight, Elegance, Elina, Escada, First Prize, First Red, Garden Party, Gladiator, Golden Gate, Golden Time, Grand Gala, Happiness, Happy Days, Lambada, Montezuma, Noblesse, Olympiad, Paradise, Pasadena, Pavarotti, Pink Supreme, Pusa Bahadur, Pusa Garima, Pusa Gaurav, Pusa Priya, Queen Elizabeth, Ravel, Saphir, Signora, Super Star, Teneke, Vivaldi, etc.

Floribunda

This rose has been derived basically from crosses between the Dwarf Polyantha and early HT roses. It grows up to 120 cm tall having more branched stems with variably prickly and hooked thorns than HT. Abundant flowers appear in clusters, bearing single to double flowers, with the plant type and flower colour similar to HTs though flower size may be smaller. Due to their profuse blooming and moderate maintenance, they are becoming more popular for mass planting in the landscaping and as cut flower. Varieties included in this type are Allgold, Angel Face, Anna Wheatcroft, Anne Harkness, Arabian Nights, Banjaran, Belinda, French Lace, Himroz, Impatient, Ivory, Iceberg, Fashion, Magic Red, Mercedez, Noorjahan, Pusa Barahmasi, Pusa Pitamber, Queen Elizabeth, Playboy, Playgirl, Sexy Rexy, etc.

Grandiflora

This is the result of crossing HTs with floribunda, attaining the plant height up to 180 cm. It produces

small clusters of large flowers more freely compared to HTs though less than floribundas. It is suitable for landscape planting, background ornamentals, and cut flowers. A few of its popular varieties are Candelabra, Caribbean, Centennial, Crimson Bouquet, New Year, Glowing Peace, Gold Medal, Love, Queen Elizabeth, etc.

Polyantha

This is a low-growing cum cold-hardy rose bearing large-clustered though smaller flowers than those of grandiflora and is excellent for mass planting, *vis-a-vis* edging. Some of the popular varieties are Anjani, Bonica, Cecile Brunner, May Wonder, Nartaki, Priti, Pusa Baramasi, Pusa Pitambar, Pusa Virangana, Rashmi, Rosa 'de Rescht', Rose du Roi, Swati, The Fairy, etc.

Miniatures

These are dwarf with high branching habit, deciduous, almost thornless, and hardy roses growing on their own roots, bearing quite little leaves and small flowers but during flowering the plants are fully adorned with blooms. These have derived from the dwarf semi-double China rose (*Rosa chinensis*). These are grown through cuttings always, as budding on to rootstocks may lose its dwarfism. These are excellent for container planting, in the rock garden, for patios, edging, in the borders, in deep window boxes and as small standards. Its leaves are mid-green with five to seven ovate and toothed leaflets. Small-clustered flowers appearing in June and July are semi-double or double with usually repeat flowering. These are of two types—those growing 30–38 cm high such as Baby Faurax, Baby Gold Star, Baby Masquerade, Coralin, Eleanor, Little Flirt, Perla de Alcanada (syn. Baby Crimson), Rosina (syn. Josephine Wheatcroft), Roulettii, Yellow Doll, etc., and other growing only up to 20–25 cm high such as Cinderella, Maid Marion, New Penny, Peon, Pixie (Little Princess), etc., so both the groups should be maintained separately. There are some climbing miniatures growing up to 1.8 m in height which make handsome specimens in the small gardens. Such roses are Magic Wand, Pink Cameo, Pompon de Paris, Showoff, etc. A few of the other noteworthy

miniatures are Aristocrat, Autumn Dawn, Black Jade, Child's Play, Creampuff, Delhi Starlet, Dreamglo, Fancy Pants, Golden Angel, Good Morning America, Honey Comb, Jean Kennedy, Kristen, Minnie Pearl, Mother's Love, My Valentine, Party Girl, Red Beauty, Santa Claus, Snow Bride, Twinkle Twinkle, etc.

Classification of Roses According to Utility

Prostrate roses

These are a small group of hardy deciduous plants with a short flowering season. These form the low hummocks or mats and make a dense cover so are quite useful for planting on the banks and on the old tree stumps. Some of the most popular varieties are *Rosa luciae wichuraiana*, 'Max Graf', 'Raubritter', etc.

Hedge roses

These are a group of roses quite suitable for planting either on a boundary or at a corner of the garden in the form of informal hedges. These are planted at usual spacing but to keep these in proper shape, these are pruned lightly. All the compact Floribundas are excellent for hedging and these are Chinatown, Dainty Maid, Frensham, Iceberg, Masquerade, Shepherd's Delight, etc. Among the old shrub roses, the Hybrid musks are quick spreading but make excellent hedges, such as Cornelia and Penelope. From the modern shrubs, Heidelberg and Queen Elizabeth (requiring regular shaping) are the best.

Shrub roses

These are strong, hardy, variably thorny or bristly deciduous hybrids chiefly between the species and old roses. These bear glossy pale to mid-green leaves with 5–7 ovate and toothed leaflets. Flowers are single or semi-double, some being fragrant, and borne as solitary or in small clusters. These grow up to 1.5 m in height and are suitable for hedging, for planting on the back of the herbaceous borders, among other shrubs and as specimen plants. Some of the popular varieties are Constance Spry, Fred Loads, Fritz Nobis,

Fruhlingsmorgen, Golden Chersonese, Golden Wings, Heidelberg, Iceberg, Joseph's Coat, Kassel, Munster, Uncle Walter, Wilhelm, Will Scarlet, etc.

Standard or tree rose

This is a man-made rose created by grafting a bush rose on a tall, sturdy and upright-growing rose plant so that it may mimic a small tree form, that is from 90 to 180 cm. Such plants provide a spectacular scene.

Weeping standards

These are made by grafting the climbers on usual rootstocks, as these grow into weeping standard roses, spreading out its branches to all the sides in cascading form. In fact, ramblers budded on a 1.2–1.8 m high stem of *Rosa canina* or *Rosa rugosa* require stakes, so the trailing stems droop to the ground as a floral skirt. These look quite spectacular when trained on an umbrella-shaped wire frame. A few varieties for the purpose are Alberic Barbier, Albertine, Crimson Shower, Emily Gray, Excelsa, Dorothy Perkins, etc.

Climbers and ramblers

These include a vast range of ascending and scrambling roses. These are normally quite vigorous plants with long spreading branches requiring support of the fence or trellis for upright and horizontal growth. Derived from roses species, these are exceptionally vigorous and quite suitable for growing on old trees and for clothing house walls with their large flower clusters for a short duration of maximum two months. Derived from Noisette roses and HTs, these are less vigorous so most suitable for growing over pillars, arbours, walls, pergolas, fences, and screens.

Ramblers are derived from *Rosa lucinae,* and are vigorous but supple-stemmed, so suitable for confined areas such as arbours, pergolas, and pillars. Climbers and ramblers may grow on their own roots or be grafted on some suitable rootstocks. Their flowering period is not as long as the HTs, but when in bloom, normally all the buds open within a few days covering the entire plant immensely. The common climbers and ramblers

NOTES

are Albertine, Blush Noisette, Caroline Testout, Casino, Chaplin's Pink Climber, Crimson Glory, Crimson Shower, Cupid, Danse du Feu, Dorothy Perkins, Dynamite, Elegance, Enna Harkness, Etoile de Hollande, Golden Showers, Marie Gouchaoult, Marechal Neil, Mermaid, New Dawn, School Girl, Summer Snow, Veilchenblau, etc.

Climate

Rose is a day neutral plant for flower initiation, and duration of light does not affect flowering. However, though for vegetative growth, it is a sun-loving plant, as during winter it requires bright sunshine at least for six hours daily and free ventilation. Temperature requirement is 24°–27°C during the daytime and 15°–17°C during night hours, that is optimum being 15°–27°C with 75 per cent relative humidity.

Soil

It has wide adaptability to soils. Deep sandy-loam with a pH range of 5.5 to 7.5 is the best soil. pH below 5.5 or above 7.5 is not congenial for growing rose. Salt-affected soils are not at all suitable for its growth. Those soils which are porous, light, water-retentive but not waterlogged and have sufficient organic matter are quite suitable for its growth. Very heavy and clayey soils can be improved through the addition of farmyard manure, coarse sand and gravel, however, the soils having a high water table should be avoided for growing rose. Alkaline soils can be improved through incorporation of organic materials.

Bed preparation

The bed preparation for rose planting should start well ahead of planting, that is, before monsoon so that applied farmyard manure or compost at 50 tonnes per hectare is well mixed and decomposed in the soil. Soil is ploughed at least thrice to a depth of 40 cm; after each ploughing the weeds, stubbles, polythene shreds and hard objects such as pieces of bricks, stones, etc., should be taken out and then planked. Third ploughing followed by planking is carried out during October, and

then beds are prepared by laying out irrigation channels and bunds.

Propagation

Roses can be propagated through seeds, cuttings, grafting, budding, and micro-propagation but commercially only through 'T' (or inverted 'T') or shield budding on appropriate rootstocks.

Seed

It is usually adopted for evolving the new cultivars, so that is the subject of the rose breeders and not of the rose growers or amateurs.

Root cuttings

Rosa blanda, Rosa nitida, and *Rosa virginiana* can be propagated even through root cuttings but usually this is not in practice.

Suckers

Own-rooting roses such as cultivars of *Rosa pimpinellifolia* and *Rosa rugosa* produce suckers, which after rooting, can be separated at the dormant stage and planted as separate plants.

Stem cuttings

Rootstocks, climbers, ramblers, polyanthas, miniatures, and all the species of rose are propagated through stem cuttings. It takes about three years to bloom from cuttings. Miniatures start flowering the same year when propagated by cutting.

Cuttings taken during the monsoon season and treated with 500–2000 ppm of IBA solution root very well. The length of softwood cuttings is roughly 10–15 cm, about 20–25 cm of hardwood cuttings and some 5–10 cm of miniatures. The cuttings should have at least three nodes, lower leaves should be removed, and one-third of the cutting should be inserted in the slanting position in the rooting medium with slanting cut to the lower side. To avoid damping off caused by *Cylindrocladium scoparium*, it is necessary to sterilise the medium.

NOTES

'T' or shield budding

Commercially, roses are propagated through 'T', inverted 'T', or shield budding as these are most popular and successful methods for rose multiplication at large scale. Best budding time in North India is from January to March, but in areas with mild climate it can be performed throughout the year. In temperate areas, the best time for budding is from mid to late summer when there is ample atmospheric humidity. In 'T' budding, the bud is inserted into a T-shaped incision on the rootstock made 7–10 cm above the ground level and tied with polythene strips. It takes 3–4 weeks for the buds to unite if temperature of the environment is 15–25°C. Original shoot is cut back 20–25 cm above the graft union after growth of the bud and emergence of new shoots.

Micropropagation

Explants taken from terminal buds, immature floral buds, and petals can be used for micropropagation. Surface sterilisation of axillary buds with 15% $HgCl_2$ for 15 minutes, then BAP 2 mg/l + 2, 4-D 1 mg/l for culture establishment, BAP 2 mg/l + GA_3 1 mg/l for shoot proliferation, and the full strength MS supplemented with 2 mg/l. IAA can be used for maximum rooting when culturing the rose plants through micropropagation, though there may be a slight difference from variety to variety.

Planting

Budded plants are planted at a suitable spacing in such a way that bud union remains 2.5–5.0 cm above the soil level. Planting should immediately be followed by thorough watering so that roots are properly settled. Planting should be carried out during October–December in South India, from October to February in the North Indian plains and Eastern India, and throughout the year in areas with mild climatic conditions. Planting in the temperate areas is done during autumn and spring.

Spacing

Miniatures are planted at 30 × 30 cm, HTs and Floribundas at 45 × 45 cm and 45 × 30 cm, and climbing roses at 1.0 m distance. Quite vigorous shrubs are planted at 75 × 75 cm and 60 × 60 cm. In polyhouses, the plant density maintained for cut flower production, is normally 7 plants/m^2 area with drip irrigation.

Nutrition

Usually, Indian soils are not deficient in potash, therefore, before the application of fertiliser, it is must to analyse the soil so that the nutrition may be applied appropriately for harvesting a good crop. As per general recommendations, for growing rose cv. 'Super Star' under open field conditions at Delhi, it should be done with 520:868:694 kg NPK/ha/year, for high density planting (30 × 30 cm). Half of the nitrogen and full doses of phosphorus and potash are supplied before planting and mixed thoroughly in the soil while the remaining dose of nitrogen can be applied after pruning, when the plants have started new growth, followed by watering.

Under protected cultivation, only liquid fertilisers are applied through manual or automated system called fertigation. Nitrogen [5:1 (nitrate: ammonium) in summer, and 10:1 in winter when soil or water has high pH] at 150–200 ppm is recommended.

Irrigation

Normally, a well grown rose plant requires 8–10 litres of water per square meter area. At no time the plants should be water-stressed, as the stress at the stage of leaf primordium formation delays the rose production cycle without disturbing the quality of the blooms. But the stress at the petal initiation stage reduces the floral bud length and number of well-formed petals, though stress before stamen initiation is most devastating as flower production may be reduced up to 70%. Irrigation intervals depend on the type of soil and season. During summer, the crop requires frequent irrigation at an interval of 4–6 days, while the crop can be irrigated after 8–10 days during winter. During rainy season, irrigate the crop if there is a long dry spell.

Notes

Special Practices for Quality Produce and Maximum Yield of Flowers

Pruning

It is the most important practice for improving floral quality and its production. This starts right from planting so that if any root is broken, that is reduced along with the cane size, leaving only 3–4 dormant axillary buds, and after start of the new growth, a 'soft pinch' is carried out of the shoots below the second 5-leaflet shoot when floral buds are smaller than pea-size, and the 'hard pinch' when its floral bud size is larger than a pea-size. Pinching structures the plant in proper architectural form for producing quality blooms. Third pruning is carried out at flower harvesting time when one, two or three nodes on the stem are to be retained or removed just below the knuckle so that flowers with long stalks are produced. Fourth pruning is carried out 4–5 weeks prior to the requirement of the flowers, and the fifth pruning is drastic which is carried out when plants have finished flowering and this way the plant height, commensurate to the variety, may be maintained from 45–90 cm, and this is known as regular annual pruning. Annual pruning revitalises the plants before start of the new flush.

Hybrid Teas

These are subjected to hard pruning to induce taller and sturdy shoots, and in this case 3–5 shoots, each with 4–5 nodes or leaves are retained, the bud of the last node facing outward. Floribundas and Polyanthas are also hard-pruned retaining 5–7 branches, each with 1–2 buds, the uppermost facing outward so that these may produce precocious flowering in clusters on shorter stems for a longer duration at different heights. Standard roses require the pruning conforming to the varieties budded onto these, first year hard pruning but subsequently only moderate to induce plenty of blooms. Climbers and Miniatures usually do not require any pruning and if need be, the unwanted part is removed with the help of scissors just to keep the plants in proper shape. In case of Ramblers, after flowering the first year,

the plants are cut back above 30 cm height, the new shoots above 30 cm length in the second year, and so on, as these bear good flowers till the last year's growth. In any case, every cut portion is pasted with Bordeaux mixture or Blitox paste. Before sprouting of the buds, an effective pesticide should be sprayed. The fertiliser should be applied only after three weeks of pruning. However, the faded flowers are regularly removed for a better look of the garden.

Bending

It is a modification of pruning to induce more floral shoots with longer stems in case of cut flower varieties grown under protection. Here, the shoots are bent as and when required, which apart from inducing more floral buds, also maintains the height of the plant at a convenient level.

Wintering

It is a practice in open-field-grown roses where 10–15 days before the annual pruning, the soil around the plants in the periphery of 20–30 cm is dug out 10–15 cm deep to expose the weak, diseased, and infested roots, and also to expose the insect-pests present there, if any, so that these are picked up by the birds and other creatures. Exposure to sun also kills certain pathogens. Exposure of weak roots may further weaken the shoots which are cut back while pruning and plants are properly shaped, and then these are watered for recovery and to initiate new growth, however, fertilisers should be applied only after three weeks of the pruning exercise.

Desuckering

This is the removal of offshoots (suckers) arising from the basal portion of the plant. Suckers try to establish themselves parallel to the main plant and share the same nutrients, space, light, moisture (soil and atmospheric), and ventilation. This affects the vigour of the main plant. Therefore, these should be removed as soon as these emerge. Since this emerges from the base, thus it is a part of the rootstock, which grows quite vigorously and as it is of no use, so its removal is always beneficial to the main plant.

Intercultural Operations

Mulching

It is the covering of the exposed surface area of the beds with black polythene or one of the organic materials to avoid direct contact of sunlight with the soil, and hence, preventing evaporation. Mulching conserves soil moisture as well as checks growth of the weeds. It also enriches the soil with organic material and in the long run, it provides humus to the soil, and maintains a uniform level of soil temperature throughout the field, which ultimately results into healthy plants and good flowering. The thickness of mulch should be 5–10 cm and material used maybe sawdust, rice husks, groundnut husks, dried leaves, chopped straw, grass and bagasse and various other waste organic farm produce. Though, polythene works for up to three years but does not supply organic matter to the field, while organic mulches gradually decomposes and supplies nutrients to the plants. Though it may take a few years, however, continuous use helps in improving the soil texture and structure continuously.

Weeding

Weeds are a nuisance in the field. These being normally fast-growers, rob the plants of their nutrients, water (soil moisture), sunlight, ventilation, and harbour various insect-pests and pathogens, which are harmful to the major crop. If these are not controlled timely and effectively, the crop may fail utterly. Since roses are perennial plants, so these encounter all sorts of weeds whether it is summer or winter. Since manually it is very expensive, so Simazine or 3-phenyl carbamate can be used effectively to eradicate the weeds in the rose field without any ill-effect on rose plants.

Staking

In open field cultivation, the plants may be supported individually with strong stakes fastened with the plants to keep them straight even during strong winds. Staking

at the initial stage of standards is very necessary. In case of protected cultivation, the posts may be erected at 3 metre intervals on both sides of the beds, and along the bed sides, galvanised wire or jute strings are tied with the posts at 30–40 cm intervals which will support the plants.

Growth and flowering

Commercial cultivars, being grown at a definite temperature range to harvest the flowers throughout the year, have no dormancy as these are recurrent and day-neutral, especially the glasshouse roses, though open field grown roses have both the types— recurrent and non-recurrent. However, CO_2 concentration in the greenhouses, irradiance, and temperature influence rose growth and development as low day temperatures of $\leq 17^{o}C$ and low night temperatures of $\leq 14^{o}C$ produce the greatest stem diameter and delayed flowering, however, increased irradiance increases the quality of floral stalk and growth rate. During winter, when the light is utterly poor, roses are provided with supplemental lighting for proper growth and development and for this, high pressure sodium lamps (HPS) at 300–1000 foot-candle (fc) for 8–24 hours/day (depending upon the cultivars, season and intensity) are provided. To stimulate axillary bud development and adventitious shoots from stem bases, the rose plants are subjected to 2–4°C temperature for 4–6 weeks.

Harvesting

Flower stems are harvested at the tight bud stage after unfurling of 1–2 petals, as earlier harvesting may cause bent-neck of stems. One flower may last from 6 to 13 days in a vase with water indoors, depending upon the varieties chosen, prevailing climatic conditions, and postharvest treatments. Immediately after cutting, the cut ends are placed in a bucket filled with distilled water and taken to the coldhouse to remove the field heat, then graded as per the stem lengths and quality of flower.

Insect-pests, Diseases and Physiological Disorders

Insect-pests

Aphids (Macrosiphum rosae and various others)

These infest on the younger leaves, shoot tips, and floral buds by clustering in large colonies. Their nymphs and adults both infest on the plants and excrete honeydew which attracts ants, and sooty mould. These also spread viruses from one plant to the other. Heavy infestation affects plant growth, hence flower quality also becomes poor. These can be controlled through frequent organic sprays of derris, pyrethrum, or insecticidal soaps. Other effective insecticides which control these pests are dimethoate, fenitrothion, heptenophos with permethrin, malathion, pirimicarb, or pirimiphos methyl.

Thrips (Rhipiphorothrips cruentatus, Scirtothrips dorsalis, Thrips maginis)

They keep on sucking the plant sap mostly from the leaf undersides and floral buds, leaving silvery trails or patches. Their infestation deforms the leaves and buds. Both nymphs and adults can be controlled through spraying 0.2 ml/l fipronil or 1.5 ml/l monocrotophos.

Fig. 2.2: Leafhopper

Leafhoppers (Edwardsiana rosae)

These are some 3 mm long pale-yellow insects (broadest at the head-end and shortly narrowing towards the tail-end) feeding on the underside of leaves, so the upper leaf surface develops a whitish mottling. Their creamy-

white nymphs may also be found crawling on the underside of the leaves. Adults can be seen jumping around when disturbed. Effective insecticides against leafhoppers are dimethoate, fenitrothion, heptenophos with permethrin, malathion, permethrin, pirimiphos methyl, and pyrethrum.

Spider mites (Brevipalpus phoenicis, Tetranychus urticae, T. cinnabarinus, Typhlodromus confuseus)

These feed on the undersurface of the leaves by webbing around, which causes white specks on the leaves. Infestation of this pest causes leaf mottling, yellowing, and falling from the plant. Monocrotophos 1.5 ml/l, propargite 1 ml/l, or wettable sulphur 3 g/l is effective in their control.

Scale insect (Aulacaspis rosae, Aonidiella aurantii, Lindigaspsis rossi)

Its infestation is shown by the formation of reddish-brown encrustations on the lower part of old stems but with little infestation on the new stems. These encrustations can be removed with a hard toothbrush or a cotton swab dipped in methylated spirit. Use of phorate 10-G or carbofuran granules at the time of field preparation or in the soil around the plants, will control this pest.

Mealybugs (Pseudococcus spp.)

These are soft-bodied pink insects covered with greyish-white powdery substance. Their nymphs and adults cluster around the growing tips, leaf axils, bud stalks, and flowers and suck their sap which causes non-opening of the buds and withering of the flowers. These also secrete a white fluffy wax, so the infested plant parts become sticky and entice the development of sooty mould. Malathion or insecticidal soap spraying on the infested parts will control these pests, provided frequent spraying is carried out. Ladybird (*Cryptolaemus montrouzieri*) predates over these.

Whiteflies (Trialeurodes vaporariorum, Bemisia tabaci)

These are small insects whose bodies are covered with a white waxy powder, and are found feeding mostly

Notes

on the leaves underside. With slight disturbance, these start flying around. Immature whiteflies are immobile and remain on the leaves underside, sucking their sap. It is very difficult to control them through chemical insecticides as these have developed resistance against many insecticides. Pyrethrum or insecticidal soap spraying thoroughly on the underside of the leaves may control these. Chemical insecticides—bifenthrin, permethrin, or pirimiphos methyl are also quite effective.

Leaf-rolling sawfly (Blemnocampa phyllocolpa)

It tightly rolls the leaflets in a fashion that the rolled leaflets often hang down. Female sawfly injects a chemical in the leaves to curl the leaflets, to insert their eggs inside the structure. Eggs are laid in the early summer, and its caterpillars start eating the leaflets after hatching, and soon these become pale-green and up to 10 mm long. Spraying of insecticides such as heptenophos with permethrin or pirimiphos methyl will control this pest.

Chafer beetle (Oxycetonia versicolor, Adoretus sp.)

Its adults feed on the floral buds, growing shoots, and leaves, while its grubs feed on the roots. Plant spraying with 0.2% carbaryl will control the adult beetles so treating the soil with 2.5 ml/l chlorpyriphos will control its grubs.

Ash beetle (Myllocerus spp.)

Its adult and grubs damage the plants similar to Chafer beetles, making irregular holes on the leaves. This may be controlled by the method used to control Chafer beetles.

Leaf cutting bees (Megachile sp.)

These nest in the hollow stems of roses, where the adults bring the stuffed leaves from roses and other plants to fill these holes to feed their larvae. While collecting the leaf pieces, they make semi-circular holes in rose leaves. These do not do extensive damage to the plants as only a few leaves are damaged but the look of the

plant is spoilt. After pruning, the cut ends of the stem should be pasted with Bordeaux paste mixed with some contact insecticide.

Termites or White ants (Odontotermes obesus, Microtermes obesi)

These are a voracious feeder of every organic matter as these inhabit large colonies much below the soil surface so the use of any effective insecticide is also unable to kill its deep-rooted queen. Water-flooding of the field is not that effective until and unless the water remains in the field for several days. Worker ants attack the plants right from planting to any further stage whenever a dry period exists. Drenching chlorpyriphos 0.5% or fipronil 0.2% near their colonies, or use of carbofuran granules at 5 g/m^2 followed by watering may prove quite effective. Neem cake is the best solution which can be used on the beds at the time of bed preparation or when mixing the nutrients in the pits.

Digger wasps (Crabro sp.)

These attack the plants after pruning by digging holes through the cut ends from where the pathogens causing dieback enter and infect the plants. Pouring a few drops of dimethoate in the hole or mixing Bordeaux paste will prevent the attack of digger wasp, and thus check the infection of dieback fungi.

Caterpillars (Helicoverpa armigera and *Spodoptera spp.)*

Its larvae feed voraciously on leaves and flowers and damage the crop seriously. If not checked timely, the whole plant may be defoliated and shoots eaten. Its attack is more devastating during the rainy season. Spraying malathion at 0.1% or cypermethrin at 0.1% is quite effective in controlling these. Their adults may be enticed towards feromone traps. HNPV (virus) also controls this pest.

Fig. 2.3: Caterpillar

Diseases

Dieback

This disease is caused by *Botryodiplodia theobromae, Colletotrichum spp., Fusarium spp., Diplodia rosarum, Leptosphaeria coniothyrium*, etc. It is a symptom of invasion by one or various pathogens, where rotting (blackening) starts in the rose plants from top to downwards, pathogens entering through the wounds inflicted by pruning or otherwise. Its initial symptoms are visible as blackening of the stem parts but afterwards, the whole plant dies. The entire affected part should immediately be cut off in one attempt with a sharp knife and should be sealed with Bordeaux paste or copper oxychloride. Spraying carbendazim 0.2% over the pruned parts will also save the plants.

Stem blight

It occurs due to the infection of any one of those fungi which cause dieback, apart from *Leptosphaeria coniothyrium*, which is well known for causing rose canker. This enters the plant through wounds inflicted at the base of the plant or elsewhere. Its infection causes the stems to show a purple or blackish patch of discolouration, and ultimate death of the plant. Such plants do not grow during spring. To solve this problem, the diseased parts are removed and burnt, the field is kept clean, excess soil or mulch kept away from the base of the plants, and proper cultivation practices followed.

Grey mould, Blossom blight or Botrytis blight (Botrytis cinerea)

From grey to grey-brown or off-white growth develops on the plants and/or its parts during humid and cold weathers, killing the blossoms and leaves, *vis-à-vis* new shoots. This fungus lives on plant debris and living part, and enters the plants through wounds or the parts which have been weakened due to burning or frost. Plant growth above the infection point is badly affected with leaf yellowing and wilting. During dry weather, petal edges shrivel, so flowers become unfit

for sale. Its spores spread due to water splash and air currents. All the dead and injured parts should be removed, debris collected, and burnt, and carbendazim at 0.2% should be sprayed to save the plants.

Black spot (Diplocarpon rosae)

It occurs on rose leaves in the form of diffused purple-black blotches which causes the leaves turn yellow and fall premature. Species roses also show small spots on their stems which may afterwards enlarge and coalesce. Occurrence of early spots on the leaves weaken the plants severely. The fungus overwinters on fallen leaves, on the bud scales, and on stem lesions. Proper sanitation should be maintained, and stems showing lesions should be pruned in spring, followed immediately by spraying of fungicides such as carbendazim, copper with ammonium hydroxide, mancozeb, penconazole, or triforine with bupirimate. Fungicides should be used repeatedly until it is completely eliminated.

Fig. 2.4: Black spot

Alternaria leaf spot (Alternaria alternata)

It causes heavy losses to the crop during the rainy season, which can be controlled by weekly spraying of azoxystrobin 0.075% or carbendazim 0.1%.

Powdery mildew (Sphaerotheca pannosa var. rosae)

It is characterised by a white powdery fungal growth appearing first on the upper leaf surface, then covering even the lower surface, the stems, thorns, and the floral buds during dry conditions. Affected

leaves may fall prematurely and the buds fail to open. The fungus overwinters in the infected stems and dormant buds. When the conditions turn favourable for the fungus again, it spreads by air. Badly infected stems should be pruned out and the plants should be sprayed with 0.2% carbendazim, mancozeb, and sulphur.

Downy mildew (Peronospora sparsa)

Its presence on roses becomes a problematic malady under tropical conditions during spring especially in the polyhouses during extended winter periods. When the weather is humid and cold and aeration around the plant is poor, its infection can be noticed. Its attack initially causes irregular purplish-red to black spots that turn yellow afterwards, followed by the falling of leaves. Its severe infection causes complete plant defoliation. To control this problem, overhead irrigation should be avoided, provision for proper aeration should be created, and the plants should be sprayed with 0.075% azoxystrobin, 0.2% mancozeb, or 0.05% metalaxyl.

Rust (Phragmidium tuberculatum, P. mucronatum)

It appears only in the temperate regions on both sides of the leaves, especially on species roses, as bright orange clustering of spores during summer and rainy seasons and the leaves fall off prematurely. During autumn, this produces winter spores to replace the summer ones. These also infect the stems at the broken point more seriously during rains. Such stems are likely to wither. The spores may overwinter on the soil surface, the plant debris and infected stems. To get rid of this problem, the air circulation should be improved in the planting, and the stems showing spring infections should be pruned out promptly. Further, the plants should be sprayed with mancozeb, myclobutanil, penconazole, or triforine with bupirimate.

Crown gall (Agrobacterium tumefaciens)

It is a soil-borne and mechanically transmitted bacterial pathogen which got introduced in India through the introduction of planting material. Its infection causes plant stunting and brownish gall formation at the crown of the plant. To get rid of such problems, the plants

should be dipped before planting for two hours in 500 ppm streptomycin solution. Infected plants should be uprooted and burnt.

Viral diseases

One such disease attacking roses is 'rose wilt', which after infection, produces recurved and brittle leaflets at the tip of the young shoots, and in severe cases even in the stems. Such leaves turn yellow and fall off whereas stem infection causes the death of the entire plant. For controlling the spread of viruses, regular control of visiting insects, especially the aphids is necessary. It would be better to uproot and burn such plants to avoid further spread.

Physiological Disorders

Rose balling

Complete or partial failure of the opening of the rose buds is called rose balling. In this case, outer petals on an unopened or partially opened bud become pale-brown, papery, and dry. Inner petals are initially unaffected but later on they may also die after the invasion of the secondary organisms. This occurs generally in damp weather when entire bud is covered with a grey mould. Possible cause is due to rains followed by bright and hot sunlight which causes scorching of the petals. To minimise this problem, only basal watering is to be done during the evening hours and not during hot sunny days. Such buds should immediately be pruned off.

Blindshoot

It is a phenomenon where new shoots emerging from the axillary buds of the previous floral stem, are without a floral bud. This occurs due to insufficient light intensity, lower temperature, and poor nutrient status of the medium.

Bent neck or Neck drooping

It is the bending of the floral buds on one side of the pedicel from the neck which occurs due to the weakening of the tissues at the neck because of the air blockage,

or microbial plugging of water-conducting vessels, thereby the water absorption is unable to match the transpiration rate, hence this problem.

Petal blackening

It occurs mostly in the case of red to maroon roses where the outer petals show blackening when exposed to strong sunlight, or in greenhouse roses when the covering sheet has no UV-B radiation protection. This occurs as the yellow pigments in red roses wither due to UV-B radiation, hence the red pigments become darker.

Nutrient deficiency symptoms

Nitrogen deficiency

It causes the leaves to turn from light green to yellow so lime may be applied when the soil pH is below 6. Nitrogen is to be applied to such plants only when pH in the field is optimum.

Phosphorus deficiency

It causes dark red to purple colouration of leaves so P_2O_5 at optimum pH may be applied, though in the case of lower pH, lime should be applied.

Potassium deficiency

It appears as drying of the leaf edges, in this case 10 g KNO_3/5 litres of water/plant should be applied and if pH is less, Ca should be applied.

Copper deficiency

Copper deficient plants show continuous wilting of young leaves so in such cases, 1.0–1.25 g copper sulphate/5 litres of water per bush should be applied.

Ferrous deficiency

It appears as yellowing of leaves with the main veins being light green. In such cases, iron chelate at 1–1.25 g/5 litres of water per bush should be applied.

Zinc deficiency

It causes large areas of dead tissues at tips and between the veins which may be corrected by correcting the soil pH and by applying zinc chelate.

Calcium deficiency

It causes hooked leaves and abortion of terminal buds which may be corrected by using calcium nitrate at 10g/5 litres of water per plant.

Magnesium deficiency

It shows leaf yellowing from the centre with the tissues dying there. This malady can be corrected by applying magnesium sulphate at 10 g/5 litres of water per plant.

Boron deficiency

It causes light green colouration of the leaves at the base along with their twisting coupled with the death of terminal buds which can be corrected by applying 5 g borax per bush.

Sulphur deficiency

It causes the leaves to turn light green, along with lighter green veins. This can be corrected by applying sulphur-containing fertiliser.

Practical Exercise

Activity 1

Identification of major rose groups.

Material required

Flowers of different groups, practical file, pen and/or pencil, etc.

Procedure

- Identify rose flowers of different groups on the basis of the following characteristics:

S. No.	Rose group	Characteristics
1.	Hybrid tea	Flower appears on solitary long cane with elongated buds, that open slowly
2.	Floribunda	Flowers are clustered but larger than polyantha

3.	Miniature	Neat, compact, and dwarf plant with clustered but smaller blooms where flowering occurs for a longer period
4.	Climber	Long canes need support to keep upright, suitable for arches, against walls, pillars, etc.
5.	Shrub roses	Perpetual flowering rose taller than bush but shorter than climbers

Activity 2

T-budding (shield budding) in rose.

Material Required

Budding knife, polyethylene strips, desired scion and rootstock

Procedure

Preparation of scion

- Take out the scion along with the bud and leaf.
- Remove the thorns and cut off the leaf leaving a portion of petiole.
- Remove the shield-shaped bud measuring 2.5 cm in length along with a chip of bud.
- Remove the chip of wood from the budding eye; the leaf petiole acts as a handle.

Preparation on rootstock

- Make a T-shaped incision about 2.5 cm long on the rootstock just below a node.
- Open the incision to facilitate the insertion of the budding eye.
- Insert the budding eye in a T-shape cut properly.
- Secure the eye by wrapping polythene tape, leaving the eye unwrapped.

Check Your Progress

A. Fill in the Blanks

1. Approximately _____ species of roses are native to India.
2. Rose hips are a rich source of vitamin _____.
3. Rose hips contain _____ times more ascorbic acid than those of oranges.

4. The result of crossing between Dwarf Polyantha and early HT roses is _____
5. The resultant class developed by crossing HTs with Floribunda is known as _____.
6. Quite cold-hardy low-growing rose, bearing large-clustered smaller flowers is _____.
7. The roses growing on its own roots are known as _____.
8. Complete or partial failure of rose bud opening is known as _____.
9. A phenomenon where new shoots emerging from the axillary buds of the previous floral stem having no floral bud is known as _____.

B. Multiple Choice Questions

1. Proper harvesting stage of rose is _____.
   (a) tight bud (b) slightly loose
   (c) half open (d) None of these
2. Bluing of rose petals is due to _____.
   (a) the accumulation of ammonia
   (b) more salt
   (c) less sugar
   (d) bacterial infection
3. Which of the following is less sensitive to chilling injury?
   (a) Rose (b) Bird of paradise
   (c) Gaillardia (d) Marigold
4. Which flower is acclaimed as the 'King of Flowers'?
   (a) Tulip (b) Rose
   (c) Carnation (d) Gladiolus
5. The time for budding in roses in North Indian plains is _____.
   (a) September–October (b) November–December
   (c) April–May (d) July–August
6. Wintering of roses in India is done normally in the month of _____.
   (a) July (b) October
   (c) January (d) April
7. Which of the following is a long stem cut rose grown in India?
   (a) Raktagandha (b) Anurag
   (c) Dr. Homi Bhabha (d) Mother Teresa

C. Subjective Questions

1. What are the deficiency symptoms of the following nutrients?
   (a) Nitrogen, (b) Phosphorus, (c) Potash, (d) Boron,
   (e) Zinc

NOTES

2. Discuss the classification of rose plants according to their utility.

3. Describe the cultural operations in rose.

4. Describe the important insect-pests and diseases of rose.

D. Match the Columns

A	B
1. Super Star	(a) Floribunda
2. Pusa Pitamber	(b) HT
3. Gold Medal	(c) Polyantha
4. Twinkle Twinkle	(d) Grandiflora
5. Pusa Barahmasi	(e) Miniature rose
6. Albertine	(f) Climber

SESSION 2: CULTIVATION OF GAILLARDIA

Botanical name: *Gaillardia pulchella*

Family: Asteraceae

Gaillardia pulchella, commonly known as blanket flower, is a native of Central United States, which is though perennial, but is grown as an annual flower.

It can be grown in gardens for bedding, at borders, on window sills, in pots, and as loose as well as cut flowers. It is grown throughout the year for landscaping, garden display, and for loose flower production (Fig. 2.5).

Fig. 2.5: Gaillardia

Varieties

Baby Cole (red flowers with yellow margin), Burgundy (wine red), Copper Beauty (orange yellow), Dazzler (bright orange-yellow petals, centre maroon-red), Firebrand (orange and maroon), Goblin (yellow and red), Golden Goblin (golden-yellow), Ipswich Beauty (orange and brown-red), Kobold (red, margined yellow), Lollypops (red or red and yellow, free-flowering), Mandarin (flame-orange and red), Picta (brown-red and golden-yellow), Picta Aurea (yellow), Red Plume (bright red), The Bride (cream-white), The Sun (golden-yellow), etc.

Climate

Gaillardia requires sunny spots for better performance. It is a long day plant but requires short days (10–12 hours) for a good vegetative growth, while long days (12–16 hours/day) with high light intensity for flower initiation, so in winters it requires supplementary lighting. It stands well to heat and drought conditions. It grows well at the temperature range of 20–30°C. The perennial

types are quite hardy and tolerate temperatures as low as –4°C. It can be grown throughout the year in plains.

Soil

It prefers soil of medium fertility with a pH range of 5.5–7.8, though survives well even up to the pH 8.5. It can be grown in various types of soils but a well-drained medium loam is best for its cultivation. Heavy soils can be improved by the addition of 20% coarse sand.

Propagation

Commercially, gaillardias are propagated by seeds, whether it is annual or perennial types, though a few of the perennial types are also multiplied through division, and root or stem cuttings. Gaillardia seeds have no dormancy, and remain viable up to 31 months, provided moisture content has been brought down to less than 9%.

Seedbed preparation

Some 15 cm raised seedbeds should be prepared for growing gaillardia. Soil should be thoroughly mixed with 4–5 kg/m^2 FYM or vermicompost, and then the soil should be made to a fine tilth through repeated ploughings, and then all the perennial rootstocks should be taken out along with other hard materials such as wood pieces, stone, crocks, polythene shreds, etc. In heavy soils, fresh coarse sand should also be mixed. The soil should be sterilised by drenching with 2% formalin and then covering it with black polythene sheets for 2–3 days and then exposed fully for a minimum of one week further before planting. Beds of convenient sizes (normally 60–100 cm width and the length as per requirement but not more than 6 metres) should be prepared and properly levelled.

Sowing of seeds

Just before sowing, the seeds should be treated with 0.2% Captan to save the plants from being attacked by damping off pathogens. The seeds should be sown thinly and evenly (3–4 cm apart in the rows, and the rows being spaced 5 cm apart) as thick sowing may cause yellowing

of seedlings, *vis-à-vis* seedlings may become prone to the infection of those pathogens that cause damping off. After sowing, the seeds are thinly covered with a finely sieved leaf mould, and then a covering of straw over it, to check the displacement of sown seeds when watering. Light watering through a fine rose nozzle by the evening must be carried out over the covering of straw. When germination starts appearing, immediately the straw is removed, otherwise seedling will become lanky and crooked. It takes about 7–10 days for germination. In nursery bed, there should be proper watering and timely removal of weeds. For winter-cropping, these are sown in September–October and for summer cropping in February–March. The seeds can also be sown in earthen pots, seed pans, or wooden seed trays.

Planting and transplanting

Seedlings are transplanted in well-prepared beds 30–45 days after seed sowing, as at this time, the seedlings have attained four-leaf stage. For bed preparation, the soil is thoroughly mixed with about 40 tonnes of well-rotten farmyard manure, ploughed deeply thrice, each time followed with planking. Polythene shreds, pebbles, brick pieces, stubbles, and perennial weed-rootstocks must be taken out before levelling and then beds of convenient sizes must be prepared. Transplanting at a distance of 45 × 45 cm is generally done either on a cloudy day or in the evening. Transplanting in the evening is always better as cool night temperatures help in establishing the plants properly. After planting, the transplants are watered immediately. Light watering every day in the early morning or late in the afternoon is required for about a week for the proper establishment of the seedlings.

Nutrition

Along with the above recommended FYM or compost (40 tonnes), 25g urea, 60–120g superphosphate, and 30–60g muriate of potash per square meter area must also be added for better results. Full dose of farmyard manure or compost along with half quantity of urea and full dose of superphosphate and muriate of potash

should also be applied at the time of bed preparation, preferably at the time of third ploughing. It can be grown best if its soil contains 15–30% clay and 0–15% bark, perlite, or sand, incorporated with 1–3 kg/m^3 complete balanced fertiliser and a little quantity of iron chelates along with other necessary micronutrients.

Irrigation

Winter crop is watered after every 10–12 days, though in summer, after every 5–7 days, looking into prevailing weather conditions and the soil types. Heavy soils require light irrigation while light soils require deep irrigation with higher frequency. Base irrigation is always better whether it is flooding or drip, though overhead irrigation is avoided for producing a healthy crop.

Intercultural operations

Plants should be supported with pegs and strings so that flowers may not be damaged through lodging. If seed production is not objective, spent flowers should be removed to promote further continuous and quality blooms. Weeds should not be allowed to flourish. For proper root aeration, the soil should also be hoed 2–3 times while taking out the weeds. Gaillardias start flowering in 90–120 days after seed sowing. Flowering during very hot summer of May–June and in the chilly weather of winter, that is December–January is utterly poor, otherwise this continues flowering throughout the year. Flowering is advanced when winter temperature is increased while continuous lighting stimulates flowering and accelerates the ageing process. Use of chlormequat and daminozide at 500 ppm or TIBA 200 ppm and kinetin 50 ppm increases the flower and seed yield.

Harvesting and display

Gaillardia flowers are harvested early in the morning, when they are fully open. For cut flower use, they are harvested with long and sturdy stems, while for loose flowers, these are harvested without stalks. For cut flowers, after harvesting, the cut ends are kept in palatable water. In vases, these remain fresh for up to

one week. For sale, the flowers are graded and bunched keeping 12 flowers per bunch. Sucrose 1% or $AgNO_3$, followed by sucrose and BA (benzyl adenine) improves the vase life considerably. For loose flowers, these are packed in large baskets and sent to the market.

Insect-pests and diseases

Four-lined plant bugs (*Poecilocapsus lineatus*), leaf hoppers (*Macrosteles fascifrons*), thrips, white flies, aphids, Japanese beetles, spider mites, and slugs and snails feed on various plant parts. Caterpillars of *Helicoverpa armigera, Plusia orichalsia,* and *Spodoptera litura* have been found feeding on gaillardia in Maharashtra. These pests maybe controlled by spraying 0.2% Rogor, Kelthane, or Malathion but slugs and snails should be trapped by spreading vegetable refuge nearby or should be killed through the use of metaldehyde baits.

Root rot or Damping off

It is caused mostly at seedling stage due to pathogens (*Alternaria alternata, Botrytis cinerea, Aspergillus, Curvularia pallescens, Dreschslera,* and *Fusarium*) present in the soil, former two causing foliar infection while others affecting seeds and seedling mortality. Dithane M-45 at 0.3% seed treatment is quite effective against all these pathogens.

Root and Stem rot

It occurs due to the infection of *Pythium, Sclerotinia, Thielaviopsis,* or *Rhizoctonia* where the lower portion of the stem becomes tan to dark brown, sometimes with white webbing of the fungal growth. Mulching that is too thick and close to the plant, as well as overwatering, should be avoided. *Sphaerotheca* and *Erysiphe cichoracearum* cause powdery wilt and in this case, both sides of the leaves are covered with powdery coating. This can be controlled through sulphur dusting and use of colloidal copper fungicide. Potassium sulphide at 0.2% spraying is also quite effective. *Entyloma* causes white smut on gaillardia plants, first appearing as light green spots on the foliage or with coloured spots in the centre, which

NOTES

become dark brown at a later stage. To avoid further infection, all the plant debris and fallen leaves should be destroyed. *Septoria gaillardiae* causes brown-flecked leaf spots with reddish-purple borders which afterwards turn ash-grey, followed by shot-holes. Infected leaves should be collected and burnt and such plants should be sprayed with Bordeaux mixture or dusted with copper fungicide. *Pseudomonas* causes interveinal leaf discolouration and bacterial leaf spots, followed by foliage turning dark-brown and the collapse of the entire plant. Aerial irrigation should be avoided and infected plant parts should be removed and burnt. If viruses such as impatiens necrotic spot, tomato spotted wilt, and CMV infect this crop, they must be uprooted and destroyed.

Practical Exercise

Activity 1

Transplanting of gaillardia seedling

Material Required

Khurpi, plastic tub, watering cane, marker, etc.

Procedure

- Water the nursery bed 24 hours before the lifting of seedling.
- Lift the seedlings with the help of a *khurpi*.
- Mark on prepared field at recommended spacing 45 × 45 cm.
- Plant the seedlings at marked spaces, probably during evening.
- Water the planted seedlings.

Check Your Progress

A. Fill in the Blanks

1. Gaillardia flowers are also known as _____.
2. Gaillardia can be grown in gardens for _____ or _____.
3. Commercially gaillardia is propagated by _____.
4. Gaillardia seeds have no dormancy and remain viable up to _____.
5. Gaillardia seeds germinate within _____.
6. Gaillardias start flowering in _____ to _____ days after seed sowing.

B. Multiple Choice Questions

1. Seed sowing in gaillardia during summer season is done in _____.
   (a) October–November (b) February–March
   (c) June–July (d) any month
2. Gaillardia is generally propagated through _____.
   (a) seed (b) roots
   (c) cutting (d) bulb
3. Gaillardia is native to _____.
   (a) Japan (b) Korea
   (c) China (d) Central United States
4. Blanket flower is harvested when they are _____.
   (a) fully open (b) half open
   (c) at bud stage (d) showing flower colour
5. The colour of gaillardia var. 'The Bride' flower is _____.
   (a) red (b) yellow
   (c) cream-white (d) orange-yellow

C. Subjective Questions

1. Discuss the climatic requirement for cultivation of gaillardia.

   _____

   _____

   _____

2. Write about the important varieties of gaillardia.

   _____

   _____

   _____

3. Write about the planting of gaillardia.

   _____

   _____

   _____

4. How is gaillardia propagated?

   _____

   _____

   _____

5. Describe the methods of bed preparation for planting gaillardia.

   _____

   _____

   _____

NOTES

6. How are the flowers of gaillardia harvested?

_____

_____

_____

7. What are the different insect-pests of gaillardia and how are they controlled?

_____

_____

_____

D. Match the Columns

A	B
1. Copper Beauty	(a) red flowers, yellow margin
2. Wine red	(b) 8.5
3. Survive up to pH range	(c) Burgundy
4. Baby Cole	(d) orange yellow

SESSION 3: CULTIVATION OF MARIGOLD

Botanical names: African: *Tagetes erecta*
French: *T. patula*

Family: Asteraceae

Marigolds (common Indian name— *gainda*) originated in Central and South America, especially Mexico, and in India, it is mostly home grown for loose flower production. They are extensively used for bedding out and on borders, for pot culture, as offerings to gods and goddesses, for making garlands, for extraction of lutein (a pharmaceutical product), as a poultry feed to increase the intensity of yolk yellowing, and also to repel and reduce the population of root-knot nematodes in the soil.

African marigold is almost a hardy, erect, and branched annual plant growing up to 90 cm tall. Its leaves are pinnatifid, composed of lanceolate, and serrated leaflets. It has single to double flowers with

large and globular heads. The flower colour ranges from lemon-yellow to yellow and orange in various shades, that is, light yellow, golden yellow, bright yellow, deep orange, golden orange, and bright orange. The florets are quilled or two-lipped.

French marigold is comparatively shorter in height (up to 60 cm), hardy, has more branches and are bushy. The shorter ones are available which grow below 30 cm in height, coming up in globular form, full of flowers, and most suitable for edging. Its stems are reddish, leaves are dark green, and pinnately divided, and the leaflets are linear-lanceolate and serrated. Flowers are small single to double. Flowers are of yellow and orange colours in various shades and crimson, light red, bicolour such as light yellow with maroon blotches, deep crimson edged yellow, gold and red, etc.

Fig. 2.6: Marigold

Varieties

African Marigold

African Orange, Apricot, Eskimo, Fire Glow, Golden Age, Golden Climax, Happy Face, Pusa Basanti Gainda, Pusa Narangi Gainda, Sunset, etc.

French marigold

Bolero, Bovita, Burpees, Butter Nugget, Cupid Yellow, Harmony, Melody, Midget, Orange Flame, Petite Gold, Red and Gold, Spun Gold, etc.

Climate

Marigolds are hardy in nature. They can grow well almost throughout the year under tropical and subtropical conditions, requiring mild climate for proper plant growth and profuse flowering. It grows well under the temperature range of 14.5 to 28°C in open area, though mostly it is grown during the winter season.

Soil

This adjusts well to a wide range of soils but with pH range of 7.0–7.5. Deep soil rich in organic matter with sandy-loam texture is most suitable for its growth.

Propagation

To maintain uniformity, under humid conditions, the varieties maybe propagated through tip-cuttings taken from vegetative plants but the easiest and best method is propagating it through seeds. It produces copious seeds so when the plants have started senescing, their mature heads having black seeds are collected, sun-dried, and the seeds are extracted. After drying, the seeds are packed in non-absorbent paper bags and stored. In the growing season, these are taken out, nursery-sown and then transplanted. Generally, 0.7–1.0 kg seeds are required for planting one hectare of land.

Seedbed preparation and seed sowing

Some 15 cm raised, 60–100 cm wide, and about 6m long seedbeds are prepared and fully pulverised soil is thoroughly mixed with sieved FYM at the rate of 4–5 kg/m^2 and fresh coarse sand must commensurate to the requirement of the soil. Nursery soil is treated with 5% formalin, followed by black polythene covering, for two days, and then full exposure for more than one week prior to seed sowing. Before sowing, the seeds

are treated with 0.2% Captan to protect the seedlings from the infection of fungi causing damping off in the nursery. Seeds are sown thinly at a distance of 3–4 cm in rows that are drawn some 5 cm apart through fingers, and thinly covered with finely sieved and well rotten FYM or leaf mould, over which straw is spread so that seeds may not be displaced while watering. Watering through fine nozzles of rose can is given each evening directly over the littered straw. After 3–4 days, the bed is regularly checked in the morning and if the nursery soil has started cracking, the straw is immediately removed to avoid the seedlings becoming etiolated or crooked. Germination usually occurs in 7–10 days of sowing if atmospheric temperature ranges between 18° to 20°C and the beds are properly exposed to sunlight. When seedlings are some 30 days old or about 10 cm high, the bed is lightly watered, and seedlings are gently removed for transplanting in the prepared beds.

Transplanting

After mixing of 40–50 tonnes/ha of well rotten organic manure or 40 quintals of vermicompost in the soil, the soil of the field is worked to a fine tilth by three ploughings or spading, followed by planking each time. Rootstocks of all the perennial weeds, stubbles, and hard objects such as pieces of woods, bricks, stones, pebbles, and grits, *vis-à-vis* polythene shreds are thoroughly removed. Field is now divided into various beds of convenient sizes, usually 1.6m wide and the length depending upon the evenness of the beds, by keeping proper provision for bunds and trenches for movement and irrigation, and then the beds are properly levelled. Planting is carried out usually during cloudy weather or in the afternoon, followed by watering so that plants recover from the lifting shock and roots establish well. For about one week, light watering should be carried out regularly to avoid any casualty. Planting is carried out at 40 × 40 cm for African marigolds, and 30 × 30 cm for French marigolds, in mid-July for obtaining flowers during autumn, in mid-October for winter flowering and in February for flowering during summer and rainy

season, however, nursery sowing of seeds is carried out one month prior to transplanting.

Nutrition

Marigolds are not a heavy feeder so if at the time of field preparation, full dose of organic manure has been applied, its fertiliser requirement afterwards becomes limited. At the time of the bed preparation, the basal dose of 80 kg of NPK per hectare can be applied in the soil, followed by transplanting. However, 60 kg of nitrogen can be applied after 40 days of transplanting and remaining 60 kg at the time when the flower buds have started coming up.

Irrigation

Frequency and timing of irrigation depends upon the prevailing weather conditions and soil type. Sandy-loam soils require more frequent irrigation than heavy soils, and summer crops require abundance of water than the winter crop when transpiration and evaporation are quite restricted. Immediately after transplanting, the crop is copiously irrigated so that its roots are well settled by the night. However, if watering has been done from plant to plant through rose can, these require daily watering at least for one week, while for summer crop, they are watered at 5–7 days interval and during winter at 10–12 days.

Pinching

Marigold plants are initially straight growing but afterwards due to emergence of many lateral branches these expand horizontally. If the terminal shoot is removed after 40 days of transplanting, side branches start emerging earlier and more number of good quality uniform flowers are produced. If the flowering is required to be delayed, the tips of all these axillary shoots are also removed which will force these shoots to form precocious tertiary shoots so more flowers will be produced, albeit the flowering will be delayed by about 10 days.

Weed control

In India, 2–3 manual weedings are required for the entire crop period. If, for up to two months of transplanting, the weeds have been controlled, due to precocious lateral branching in the marigold plants, weeds do not get the opportunity to germinate and flourish, so for only the first two months of transplanting the weeding is required. In the first fortnight, weeding is not required as the field remains already clean at the planting stage. Chemical weed control with granular formulation of Simazine 2.0 kg/ha or Chlormequat at 5.0 kg/ha applied as post-planting, has been found effective in controlling almost all the weeds.

Harvesting

Flowers in marigold are harvested manually at fully-open stage, though still compact, usually by the evening when the weather has become cool but dew has completely dried up.

Depending upon the varieties planted, prevailing climatic conditions and cultural practices adopted, yield of flowers in African marigold ranges from 11–22 tonnes/ha (1.5–2.5 millions/ha) and 6–15 tonnes/ha (8–12 millions/ha) in French marigold.

To avoid dehydration, after harvesting the flowers are covered with moist hessian cloth/gunny bags when stored only for a night and next day taken to the market, however, at 8°–10°C these can be stored for up to three days. For local markets, these are either taken in large polythene or gunny bags but for distant markets, they are taken in the baskets of various sizes. The shelf life of loose flowers can be extended by soaking them in 0.1% Aluminium sulphate [$Al_2(SO_4)_3$] for two hours.

Insect-pests

Red spider mites *(Tetranychus urticae)*

These are brown and red spinning creatures which become a nuisance during the dry and hot weather in the outdoor plantings. These continue sucking the cell

Notes

sap of the tender plant parts. Their attack causes plants to look dusty and discoloured. These can be controlled by spraying with kelthane at 2ml/l of water.

Bud boring

Young larvae bore into the growing flowers and feed on various floral parts and foliage. Hand-picking and killing is effective when these are first seen but when these are in plenty, the plants are sprayed with 0.1% methyl parathion.

Hairy caterpillar *(Diacrizia obliqua)*

It is a polyphagus insect, its caterpillars feed on every part of the plant. It is controlled by spraying with Malathian or Dimethoate 2ml/l.

Aphids *(Aphis gossypii)*

These are tiny sap-sucking insects clustering at the tender plant parts, and produce honey dew to attract sooty mould. Its infestation causes deformity on the infested parts and spreads the virus infection. These can be controlled through forced water spraying and spraying with Malathion 0.2% or Dimethoate 0.03% at 10–15 days interval.

Thrips *(Frankliniella occidentalis)*

These also feed on the plants by sucking the sap, and spreading tomato spotted wilt virus. Controlling the aphids will control the thrips also.

Leafhopper *(Empoasca fabae and Macrosteles fascifrons)*

These are hopping insects and survive by sucking the sap of the plants. Their infestation causes leaf rolling and curling at the edges and when the attack is serious, tip wiltings are observed. At initial infestation, spraying Malathion or Dimethoate 2ml/l twice or thrice is quite effective.

Diseases

Alternaria leaf spot *(Alternaria tagetica)*

It appears as minute, purplish-brown, and circular spots on leaves and stems which enlarge afterwards

and girdle the stem. Mancozeb at 0.25% spraying will control it effectively.

Flower bud rot *(Alternaria dianthi)*

It appears as rot of the floral buds and its infection causes older leaves to develop a few deep brown necrotic spots, and in humid weather, its infection becomes serious. This is controlled with 0.2% Dithane M-45 spraying at fortnightly intervals. Flower bud rot is also caused through the infection of *A. alternata*. This becomes serious in humid weather. Its control is the same as that of *A. dianthi*.

Marigold blight *(Colletotrichum capsici)*

It infects petiole, peduncle, and branches. Dithane 0.2% spraying will control this problem.

Septoria leaf spot *(Septoria tageticola)*

It causes oval to irregular and gray to black spots with tiny dots of fungal fruiting structures from lower to upper leaves. It is controlled with 0.2% mancozeb spraying.

Cercospora leaf spot *(Cercospora thunbergiae)*

It produces brown and circular-oblong spots on the leaves of *Tagetes erecta*. However, leaf-spot or blight (*Cercospora tageticola*) on French marigolds causes dark brown circular spots with a prominent grey margin. On French marigold, leafspot or blight (*C. tagetis*) causes indefinite, irregular, and blackish coalescent spots. All these can be controlled by spraying 0.2% mancozeb.

Fusarium wilt *(Fusarium oxysporum)*

It occurs in the field. To some extent, this infection can be checked by drenching the plants with carbendazim 2g/litre. Thiride at 0.2% drenching may control this pathogen.

Rhizoctonia solani

The symptoms appear as brown necrotic spots and girdling of the radicle which extends later to plumule and thus, pre-emergence mortality of seedlings takes place. Under post-emergence symptoms, lower part of

hypocotyls develops water-soaked, brown, and necrotic rings leading to the death of seedlings. In these seedlings, the root system is partially or fully decayed. For control, ensure proper drainage in the nursery beds, and nursery soil should be drenched with Brassicol at 0.3%.

Powdery mildew

It is caused by fungus *Oidium* sp. and *Leveillula taurica*, which appear as whitish and tiny superficial spots on leaves, which later on spread to the whole aerial parts, ultimately covering the entire plant with whitish powder. It is effectively controlled through 0.5% Karathane (40 E.C.) spraying or dusting of the plants with wettable sulphur at an interval of 15 days.

Bacterial leaf spot

It is caused by *Pseudomonas cinereal,* which can be controlled through spraying with 0.03% streptomycin.

Virus

CMV causes mosaic pattern, and MLOs cause 'aster yellows'. These appear as yellowing or clearing of the veins in leaves, shortening of the internodal regions of the main stem, and production of long axillary breaks so it looks like witch's broom, and sometimes forming even phyllody where floral parts convert to greening. Its vectors are leafhoppers. CMV is a serious problem during the rainy season which causes streaking or mottling of leaves and growth stunting. Its vector is aphid, so its control with Malathion or dimethoate at 2 ml/l at regular intervals will keep this malady under check.

Physiological disorders

Bronze speckling

It appears on African marigold cvs 'First Lady' and 'Voyager', probably due to iron toxicity, where chlorosis and necrosis, along with the downward curling and cupping of leaves takes place. The iron level in the leaf tissue should not exceed 500 ppm to avoid iron toxicity.

Leaf burn

It appears as yellowing and death of the tips and margins of the leaves due to excess of boron, manganese, or molybdenum. Leaf tissue levels of Mn, Mo, and B should not exceed 55 ppm, 24 ppm, and 3 ppm, respectively.

Practical Exercise

Activity 1

Identification of marigold species

Material required

Practical file, pen, pencil, plant material, etc.

Procedure

- Identify marigold species on the basis of the following characteristics.

S.No.	Marigold Species	Characteristics
1.	African marigold Tagetes erecta	• Plants are erect and tall in height up to 90 cm. • Leaves are light green. • Stem is greyish. • Flowers are globe shaped and large. • Size of flowers maybe up to 13 cm across. • Colour of flowers is yellow, orange but not red.
2.	French marigold Tagetes patula	• Plants are bushy and short in height, up to 60 cm. • Its stem is reddish. • Its leaves are dark green. • The colours of flowers are red, orange, and yellow. Red and orange bi-colour patterns are also found. • Flowers are smaller (5 cm across).

Activity 2

Pinching operation in Marigold

Material required

Forceps, Marigold crop, practical file, pen, pencil, etc.

Procedure

- Pinching operation at 20th, 30th and 40th day after transplanting.
- Select plants in the field for pinching.
- Record the observations as per specification.

Take the observation on the basis of given parameters

S.No.	Parameters	Observation
1.	Plant height (cm)	
2.	Number of branches (no.)	
3.	Days taken for first flower bud initiation	
4.	Duration of flowering	
5.	Size of flower	
6.	Weight of flower (g)	
7.	Number of flowers per plant	
8.	Flower yield (g)	

Result: On delaying pinching operations, various parameters differed in their values such as _____.

Check Your Progress

A. Fill in the Blanks

1. Botanical name of French marigold is _____.
2. Marigold belongs to family _____.
3. Planting marigold in the field reduces the population of _____ in the soil.
4. Marigold can be vegetatively propagated through _____.
5. Commercially marigold is propagated through _____.
6. About _____ kg seeds of marigold are required for planting one hectare of area.

B. Multiple Choice Questions

1. Among the following, who is associated with Marigold breeding in India?
   (a) B. Singh (b) R.L. Misra
   (c) M.L. Choudhary (d) S.P.S. Raghava
2. Nugget is a cultivar of _____.
   (a) Marigold (b) Rose
   (c) Tulip (d) Carnation
3. Native place of Marigold is _____.
   (a) Russia (b) South Africa
   (c) Mexico (d) India

4. Recommended seed rate of marigold is _____.
   (a) 0.7–1.0 kg/ha (b) 2–3 kg/ha
   (c) 3–5 kg/ha (d) 7–8 kg/ha
5. Optimum temperature required for Marigold cultivation is _____.
   (a) 6–14°C (b) 15–28°C
   (c) 30–42°C (d) All of these
6. Among the following, which one is the African marigold variety?
   (a) Orange flame (b) Melody
   (c) Bolero (d) Golden climax

C. Subjective Questions

1. Differentiate between African marigold and French marigold.

   _____
   _____
   _____

2. How useful is pinching in marigold?

   _____
   _____
   _____

3. Describe the harvesting of marigold.

   _____
   _____
   _____

4. Write about the bronze speckling of marigold.

   _____
   _____
   _____

5. Give the symptoms and causes of leaf burn in marigold.

   _____
   _____
   _____

D. Match the Columns

A	B
1. Planting stage	(a) Tagetes patula
2. French marigold	(b) 4 leaf stage
3. Pusa Basanati gainda	(c) Wettable sulphur
4. Powdery mildew	(d) African marigold

NOTES

Session 4: Cultivation of Jasmine

Botanical name: *Jasminum auriculatum, J. grandiflorum, J. officinale, J. sambac, etc.*

Family: Oleaceae

Jasmine, a native of tropical and sub-tropical regions, is one of the most important traditional cum loose flowers, valued for its intense fragrance in the country and for extraction of essential oil. The species is available in both shrubby and climbing forms. Out of about a total of 40 species, India accounts for 20 species. Its flowers and flower buds are used for making garlands, *gajra*, *veni*, vis-a-vis for religious offerings. Their flowers also yield a high grade essential oil which is used in manufacturing perfumes, cosmetics, creams, hair oils, soaps and shampoos. From economic point of view in India, four species, *viz.*, *Jasminum auriculatum, J. grandiflorum, J. officinale,* and *J. sambac* are the most important as these contain a high percentage of essential oil. However, *J. arborescens, J. calophyllum, J. flexile, J. humile,* and *J. pubescens* also have high ornamental value (Fig. 2.7).

Fig. 2.7: Jasmine

Varieties

Jasminum auriculatum

Aureum, Co-1 Mullai, Co-2 Mullai, Long Point, Long Round, Madanban, Medium Point, Mogra, Motia, Palampur, Parimullai, Short Point, and Short Round. Parimullai is a clonal selection with 0.29% concrete recovery while Co-1 Mullai has 0.34% concrete recovery.

Jasminum officinale

Affine and Aureum (Aureum Variegatum)

Jasminum grandiflorum

Arka Surabhi, which is drought tolerant and has 0.35% concrete

recovery, Bangalore, Coimbatore, Co-1 Pitchi, Co-2 Pitchi with 0.3% concrete recovery, Lucknow, Pintype, Thimmapuram, Thrumtype, and Triploid.

Jasminum sambac

Arka Aradhana, Bela, Ramabanam, Double Mogra, Gundumalli, Hazara, Single Mogra, Iruvatchi, Kasthurimalli, Khoya, Madanban, Motia, Oosimalli, Eai Japanese, and Soojimalli.

Climate

Though most of the species are native to tropical and sub-tropical regions but a few are hardy as are recorded from temperate regions so accordingly these can be grown in the country having conditions akin to their requirement. However, in general, mild tropical climate with warm summer and mild winter, that is, 14–27°C temperature is excellent for proper plant growth and flower production in most species.

Soil

Any soil which is fully exposed, well-drained, aerated, and rich in organic matter is suitable for jasmine cultivation. However, optimum soil is that which has sandy-loam texture with a pH range of 5.0 to 8.0.

Propagation

Jasmine can be propagated through seeds, though seed-setting is very rare and also seed-raising is the job of a breeder for developing new varieties. It is commercially propagated through cuttings and layering.

Commercially, cuttings are the easiest way of producing a number of plants from one plant. Softwood central cuttings having at least two leaves and 15–20 cm length are taken mainly in March and also in June, July, September, or October and inserted in the propagation media [sand, vermiculite, sphagnum moss, peat, or various combinations of these, best being coarse sand, followed by sand + moss (1:1 to 1:3)] at an illuminated place. It takes 6–10 weeks for rooting, depending upon the species or cultivar chosen and prevailing climatic conditions. In case of layering, it is

simple layering, practised from June/July to October/ November, and it takes 90–120 days for removal. Since, it is time-consuming and only a few plants are prepared from one plant, as after bending the shoots are buried in the soil and pegged to remain in the position so one shoot yields only one layer. As in *Jasminum auriculatum* and *J. grandiflorum,* the propagation through cutting, is not so successful, these are propagated through grafting and patch budding.

Land preparation

The field is deeply cultivated to a depth of about 40 cm and the soil is fully pulverised after thoroughly mixing 40–50 tonnes/ha of FYM/compost in the soil. All the stubbles, rootstocks of perennial weeds, hard objects such as pieces of woods, bricks, stone tiles, and shredded polythene sheets are removed while preparing the beds. Depending upon the growth size of the species and varieties, the pits are prepared of 45–90 cm^3 and then these are filled with topsoil mixed with about 100 grams of carbofuran per pit and then exposed for a week. In case the beds are not fortified with FYM at the time of field preparation, at the time of pit-filling, some 10–25 kg of FYM is added per pit and mixed thoroughly with the soil.

Planting

Usually the planting is carried out during the rainy season when the soil has sufficient moisture and air is quite humid so that plants are saved from casuality. Density of the plant depends upon the species, cultivar, and the soil and environment of the growing area. The spacing provided for various popular species and their varieties are 1.2×1.2 m for *Jasminum sambac*, 1.5×1.5 m for *J. Grandiflorum,* and 1.8×1.8 m for *J. auriculatum.*

Nutrition

At the time of pit-filling, more than 10 kg of FYM is added per pit, along with 120–240 g N and equal quantity of potassium, better if nitrogen is given in split doses. P_2O_5 requirement is almost double that of nitrogen. Since this is a perennial crop and remains in the field in every season so it is better if all the fertilisers are applied in

two split doses, once in February and the other in July. However, split application in case of *J. grandiflorum* and *J. sambac* is not so responsive.

Irrigation

Since these become dormant during winter in the subtropical regions of India, so usually, they do not require regular watering, however, care should be taken that soil does not become completely dry, otherwise this may prove disastrous for the plants. Therefore, occasional light watering at 20 days intervals maybe applied. In summer, especially May and June, it is quite hot so, at this time, these require copious cum frequent watering at 5–7 days intervals. During the rains, the same depends on the weather conditions, but if there is no rain, March–April and again during autumn too, These can be watered weekly. When it begins to grow during spring, it should be watered copiously.

Weed control

Weeds are the greatest trouble in the crop during the initial growth period so if not controlled timely, they may cause enormous crop loss. Weeding in jasmine plantation in India is carried out only manually, though it is quite expensive. However, thick organic mulching is very effective in keeping the jasmine weeds under check, which together provides humus to the soil through gradual decomposition. Use of Oryzalin weedicide is quite economic which controls the weeds for up to 70 days, by then the crop is almost fully grown, and then the weeds do not get a chance to grow. Paraquat at 2 kg/ha are also quite effective.

Pruning

It regulates plant growth and flowering. For pruning, the watering is first withheld and then, all the past season shoots are pruned along with straggling and diseased branches to promote the emergence of new shoots on which flowers are produced. Immediately after pruning, the injured plant parts should be pasted with Bordeaux paste so that no pathogen may enter through the pruned parts. Bordeaux paste should be applied on the cut ends to check the entry of the pathogens.

For pruning, certain defoliants such as paraquat dichloride, pentachlorophenol, potassiumchloride, and sodium chloride can be used to some extent. *Jasminum auriculatum* should be pruned prior to 15 days of it taking new growth, that is the middle of February, while in case of *J. grandiflorum*, the pruning may be carried out in any month to obtain a good flower yield, however, the best time being the last week of December. *J. sambac* can be pruned from October to January for harvesting to get the highest flower yield. Pruning is carried out from 15 to 90 cm from the base having 3 to 13 nodes intact on the plant, and pruning at 90 cm length from the base with 13 nodes produces more number of branches with improved yield in case of *J. grandiflorum*. However, *J. sambac* requires only low pruning.

Harvesting and yield

Flowering in jasmine may start in the first year of its planting but usually it starts from the second year, though economic yield is obtained usually from the third year. The stage of flower harvesting depends upon the purpose for which flowers are required. Picking is always carried out early in the morning. For use as fresh flowers, fully developed but little opened flower buds are picked, whereas fully opened flowers are picked for extraction of concrete. In India, jasmine flowers are harvested through the hand picking method though in other countries these may be harvested through suction harvester. For marketing, these are packed loosely in small bamboo baskets for local markets, and in corrugated cardboard boxes for distant markets.

Flower and concrete yield may vary as per the species used, cultivars grown, and management practices followed. In general, the flower yield in jasmine is 8,000–10,000 kg/ha, in case of *J. auriculatum* it is 4,700–9,000 kg/ha with concrete recovery of 0.26–0.28%; in case of *J. grandiflorum* the flower yield is 4,000–10,000 kg/ha with concrete recovery of 0.25–0.32%; and in case of *J. sambac,* the flower yield is 7,000–8,000 kg/ha with concrete recovery of 0.14–0.19%. It is only *J. grandiflorum,* which has international market for its concrete and its variety 'Co. 1 Pitchi' which produces

over 10 tonnes of flowers per hectare with an estimated concrete yield of 29 kg with a recovery of 0.29%.

Insect-pests and Diseases

Insect-pests

Budworm (Hendecasis duplifascialis)

Its caterpillars bore the blossoms and feed on developing petals, especially in *J. sambac,* and fill the excreta in the hole of the buds so the buds become pink and fall prematurely. This can be controlled through spraying with 5% neem kernel extract, and during the off period the soil should be exposed so that the birds and predatory insects may feed over the exposed pupae.

Galleryworm/ shootworm/ budworm (Elasmopalpus jasminophagus)

It is a serious pest on *J. auriculatum,* and its larvae feed inside the buds making exit holes at the base. It webs the terminal leaves, shoots, and flowers.

Shoot borer (Sycophila sp.)

Its larvae infest on *J. grandiflorum,* making tunnels inside the shoots and pupating there. This is controlled through spraying with 0.02% Nuvacron.

Leaf webworm (Nausinoe geometralis) and leafroller (Glyphodes celsalis)

Its caterpillars feed on the lower leaves during rains and on the terminal shoots during dry seasons. These are controlled through 2 ml/l spraying of Hostathion during the peak period of infestation.

The nymphs and adults of tingid bug (*Corythuma ayyari*), jasmine bug (*Antestiopsis cruoiata*), and green plant hopper (*Flata oellata*) feed on the plant cell sap of the tender parts, by which leaf yellowing and falling are caused. All these are automatically controlled while controlling the leaf webworm.

Blossom midge/ gall fly (Contarinia maculipennis)

This infests on *J. auriculatum* and *J. sambac*. Its maggots enter through corolla bases and destroy the buds. This is controlled by spraying with 0.1% Flufenoxuron 10DS.

NOTES

Nymph and adult thrips (Isothrips orientalis, syn. Thrips orientalis)

These suck the plant sap from the buds and flowers causing brown streaking on the petals and their falling off. Control measures are the same as in case of worms.

Cyclamen mites (Steneotarsonemus pallidus, Tetranychus urticae)

These feed on *J. sambac* and eriophyid mites (*Aceria jasmini*) feed on *J. auriculatum* and *J. pubescens,* these continue feeding on the leaves, buds, and tender stems so the plant growth is hampered and flower production is reduced. Gall mite (*Eriophyes* spp.) is a havoc in South India and devastates *J. auriculatum* crop during the rainy and winter seasons by burrowing under the epidermis of the leaves and tender shoots causing whitish bloated galls which coalesce later, causing drastic reduction in the flower yield. 'Parimullai' is resistant to this pest. Spraying and rubbing of Rogor on the affected parts will control these pests.

Root-knot nematodes (Meloidogyne incognita)

These have been found feeding and galling on jasmine roots, thereby causing foliage yellowing, and in severe attack, the plants even die. It can be controlled by the application of neem cake at 1t/ha or Carbofuran granules at 2.5 kg/ha in the soil, followed by watering.

Diseases

Leaf blight (Alternaria jasmini and Cercospora jasminicola)

It causes brown spots on the leaves, irrespective of their age, though young branches present clear symptoms. During humid conditions, these spots coalesce, blight, leaf margins curl inward, and finally the leaves fall off prematurely. This problem is very serious for *J. grandiflorum.* Immediately after appearance of the disease, the crop should be sprayed at 'run off' stage with mancozeb 0.2% or carbendazim 0.1% and repeated once after 7–10 days. Soil application of *Pseudomonas fluorescens* at 25 g/m^2 and its 0.5% foliar spraying at 25–30 days intervals will effectively control the disease.

Leaf spot (Curvularia paradisi)

It causes brown spots and leaf defoliation which may be controlled through a fortnightly spraying of 0.2% Dithane Z–78.

Wilt/ root rot (Fusarium solani, Sclerotium rolfsii, Clitocybe tabescens)

It appears as whitish colony having abundance of micro and macro conidia with chlamydospores. Twice drenching fortnightly with benomyl 0.1% + copper oxychloride 0.3% and carbendazim 0.2% + copper oxychloride 0.3% will control this problem.

Powdery mildew (Oidium jasmini)

It spreads through wind-borne conidia and appears as white powdery patches on the upper leaf surface. These patches afterwards coalesce and cover the entire leaf surface. Wettable sulphur at 0.2 per cent or carbendazim at 0.1 per cent spraying will control this disease.

Rust (Uromyces hobsoni)

It appears on both sides of the leaves (lower side being more conspicuous), and sometimes on stems during humid weather, leaves showing orange aecial cups, and after sometime the entire leaf becomes yellow and crinkled, and the stems start splitting of bark and finally the branches die. It is controlled with 0.15% copper oxychloride or 0.2% zineb spraying.

Chlorotic ring spot virus

It spreads through whitefly (*Bemisia tabaci*) and grafting, but not through the sap and is characterised by the development of typical mosaic symptoms consisting of yellow chlorotic spots on the leaves. The disease is controlled by controlling the vector through Acetamiprid 20 SP at 15–20 g a.i./ha spraying. Jasmine mosaic virus causes little leaf, mottling, and chlorotic flecking, *vis-a-vis* stunting and yellowing of the entire plant. The disease spreads through insects and grafting, therefore, it is essential to control the vectors. Phyllody (mycoplasma) transforms the flowers into malformed and reduced greenish flower-like structures with greenish and ovate corolla lobes. Such plants are not suitable for taking

further cuttings for multiplication. The disease can be controlled through spraying with 250 ppm of tetracyclin hydrochloride. Virus infected plants should be rogued out and burnt.

Practical Exercise

Activity 1

Identification and collection of different species of jasmine.

Material required

Herbarium files, transparent sticking tape, sketch pen.

Procedure

- Identify different species through their leaf and floral characteristics.
- Collect the sample of different jamine species.
- Dry the sample of species separately.
- Stick the sample on herbarium page.
- Write the special characters of the species beside the pasted sample.
- Keep the herbarium file in a dry and cool place.

Activity 2

Calculate the cost of cultivation of jasmine per hectare.

Procedure

- Collect the data from the cultivator.
- Summarise the data in the table.
- Calculate the cost of cultivation of jasmine per hectare.

Particulars	Cost (₹)
A. Land lease cost (₹ _____/ hectare)	
B. Material cost	
• Planting material (_____cuttings/hectare; ₹ _____ /cutting)	
• Farmyard manure (_____kg/_____; ₹ _____/kg)	
• Fertilisers/hectare — N (____ kg @ ₹___/kg); P_2O_5 (_____ kg @ ₹ _____/kg); K_2O (_____ kg @ ₹ _____/kg); other fertilisers (_____@ ₹_____/kg)	
• Charges for irrigation	
• Weed management (₹_____/hectare)	
• Plant protection chemicals (₹____/hectare)	
• Fencing (Live Hedge)	
C. Operation and labour (excluding labour on harvesting) _____ man days/hectare; ₹ ____/ man days	

D. Harvesting charges (₹ _____ /kg of flowers)	
E. Transportation cost ₹ _____	
F. Miscellaneous (₹_____/ha)	
G. Production (_____kg/hectare)	
H. Total income (production _____ kg/hectare _____ @ ₹_____ /kg)	
Total cost: (A to F ₹_____/hectare)	
Net income: (Total income – Total cost) ₹_____/ hectare	
Benefit cost ratio (B:C): Total Income/Total Cost	

Conclusion: On the basis of Total income and Total cost, calculate cost and benefit ratio.

Check Your Progress

A. Fill in the Blanks

1. In India, about _____ species of jasmine are found.
2. For its concrete, _____ has an international market.
3. Jasmine is propagated by _____.
4. Dormancy in most of the *Jasminum* species is observed during _____.
5. The easiest way of propagating jasmine is _____.
6. Seedlings of jasmine can be planted during the _____.
7. Yield of Jasmine flower is _____ tonnes/ha.

B. Multiple Choice Questions

1. Among the following, which one is the substitute for saffron?
   (a) Jasmine (b) Tulip
   (c) Rose (d) Carnation
2. Climate requirement for jasmine is _____.
   (a) temperate (b) tropical
   (c) sub-tropical (d) All the above
3. For jasmine oil extraction, which stage of flower is suitable for plucking?
   (a) Tight (b) Half open
   (c) Fully open (d) None of these

NOTES

4. Jasmine is propagated through _____.
   (a) soft wood cutting
   (b) semi-hardwood cutting
   (c) hardwood cutting
   (d) seed

C. Subjective Questions

1. Write down the importance of jasmine.

_____
_____
_____
_____

2. Describe jasmine propagation.

_____
_____
_____
_____

3. Discuss flower harvesting of jasmine.

_____
_____
_____
_____

4. Describe jasmine pruning.

_____
_____
_____
_____

5. Explain planting spacing for different jasmine species.

_____
_____
_____
_____

D. Match the Columns

A	B
1. Parimullai	(a) Fully open flower picked
2. For extraction of concrete	(b) *J. sambac*
3. Arka Aradhana	(c) *J. grandiflorum*
4. Arka Surabhi	(d) *J. auriculatum*

Session 5: Cultivation of Crossandra

Botanical name: *Crossandra infundibuliformis*

Family: *Acanthaceae*

Crossandra, commonly known as 'Firecracker plant', due to the cracking sound produced during the splitting of seed-pod, is an important loose flower crop, especially in South and East India. About 50 species are there but only *Crossandra flava* (bright yellow flowers), *C. infundibuliformis* (orange), *C. guineensis* (pale-lilac to white bracts), *C. mucronata* (bright orange to dark red), *C. nilotica* (yellow-orange to brick red), *C. pungens* (orange or yellow), *C. subacaulis,* and *C. undulaefolia* (calyx bright orange and bracts salmon to scarlet-orange) are in cultivation. It is native to Arabian Peninsula, Tropical Africa, Madagascar, India, and Sri Lanka. In South India, where it is a commercial crop, its cultivation is estimated to be more than 4,000 hectares. This is also a valuable pot flower in Denmark, Sweden, Hungary, and Sri Lanka. In Denmark, commercially they grow only cv. 'Deep Orange' (a triploid).

It is a small, evergreen, and herbaceous shrub for tropical regions which has the ability to produce beautiful flowers with a remarkable range of colours, almost round the year. In India, crossandra ranks fourth next to rose, jasmine, and tuberose in loose flower production. Flowers though are very attractive, light, and durable but not fragrant; therefore its flowers are mixed with jasmine for hair adornment, besides being used for making garlands either alone or with jasmine flowers. Crossandra can be grown in pots, home gardens, rockeries, and in herbaceous borders. It starts flowering 2–3 months after planting, flowers throughout the year, with a drop in the rainy season.

Varieties

Three forms such as yellow, deep orange, and subacaulis red are grown to a small extent. The deep orange type being triploid does not set seed, as is the case with Mona Wallhead, a cultivar, which is grown in Denmark. Variation available in crossandra is very

low as compared to other flowers even then there is a remarkable range of colours, varying from yellow to red via pink to orange, and double coloured blue types with white throat. Recently white, light green, and violet types have become popular. Important varieties of crossandra developed by various agencies are:

Fig. 2.8: Crossandra

Mona Wallhead

An introduction from Sweden, it grows up to 50 cm tall with compact growth habit where leaves are shiny black-green and the irregularly-shaped flowers are deep salmon to pink with prominent bracts. Fortuna, bearing quite glossy foliage, and bearing attractive bright flowers for a longer duration is a selection which has extended the plant life. It is quite resistant to temperature fluctuations due to greatly improved root system and tolerates temperatures as low as 10°C.

Diane

A new and robust form of the species, *C. infundibuliform* has a compact growth bearing large and wide leaves, flowers dark salmon-orange, and petals much larger and rounded than the commonly cultivated variety.

Savindi

It is a pink-flowered mutant.

Danica

It has orange flowers, developed through *in vitro* gamma irradiation.

Lakshmi

It is a high yielding (up to 75 kg flowers per day per hectare from the second year of planting) gamma irradiated mutant developed through cv. Delhi, and bears large orange flowers.

Maruvur Arasi

It is a high yielding bright deep-red variety with longer floral stalks, bearing over 75 flowers per stalk, developed through cv. Delhi by gamma irradiation.

Dr. A.P.J. Abdul Kalam

It is a deep red variety developed through cv. Delhi by gamma irradiation, which is resistant to major pests and flowers round the year.

Kanakadhara

It is a mutant of cv. Delhi developed through chemical mutagenesis (sodium azide). It is a vegetatively propagated crossandra, which produces brilliant orange flowers yielding 25% more flowers than the mother cultivar.

Vijaya Kanakambaram

It is a tall mutant of free-branching and profusely flowering type having stout stems, bearing long inflorescences with large light reddish-orange flowers. It was developed through seed treatment of a local cultivar with colchicine, which yields 75 kg flowers per day per hectare 90 days after planting.

Raj Kanakambaram

It is a leaf-variegated mutant of cv. Delhi with deep orange flowers bearing 15 cm long inflorescence and has the potential of producing up to 75 kg flowers daily per hectare through proper management practices.

Subasu

It is a mutant of cv. Delhi with long inflorescences bearing light orange flowers of medium size.

Neelambari

It is a mutant of Local Yellow cultivar, bearing dense green foliage and normal size of flowers on long inflorescences.

Arka Ambara

It is a cross of Local with *Lakshmi* with large flowers, where flower weight is roughly double of the cv. Local.

Arka Kanaka

It is a cross of Local Yellow with Delhi with large and showy orange flowers which weigh roughly double of the mother parent.

Tropic Flame

It is an orange-flowered cultivar evolved in USA which multiplies through seeds.

Florida Series

It is more tolerant to cold than others, is vegetatively propagated and has four colours, *viz.*, yellow, orange, red-orange and red.

Aboli

It is a variety of *C. undulaefolia* and is grown in Andaman and Nicobar Islands.

Climate

Crossandra is a crop suited to tropical areas as it cannot tolerate temperature below 13°C and dies when frost occurs. It performs well in warm and humid areas with temperature ranging from 20 to 32°C. luxurious growth occurs at 30°C. A temperature of 25–28°C is most ideal for seed germination, while for cotyledon emergence and true leaf expansion, a temperature of 21–22°C is required. It can survive the optimum minimum night temperature of 18–24°C, while the minimum day temperature requirement is 21–28°C. Warm temperatures and long summer days encourage the flowering.

Soil

Crossandra can be grown in almost all types of soils. However, well-drained loamy soils rich in organic matter with a pH of 6.0–7.5 are most suited. Wherever it is to be grown, the soil should be free from nematodes. Alkaline, saline, clay, or heavy soils are not suitable as in the former two types of soils plants develop deficiency symptoms, such as chlorosis leading to improper growth of plant and poor flower production, and in the latter two cases, waterlogging may cause death of plants. Plants raised through seeds require 31 weeks to attain marketable size, though from liners, it requires 12–14 weeks, albeit it takes additional 6–7 weeks for producing liners from rooted cuttings.

Propagation

Crossandra is propagated through seeds, stem cuttings, and layering. Triploid varieties are propagated only through cuttings as these do not set seeds. For one hectare of planting it requires 2.0–2.5 kg of seeds as in one gramme, it contains some 140–200 seeds. A spacing of 50 × 50 cm has been reported as ideal for seed production. Physiological maturity in crossandra seeds is attained in 55–60 days after flowering and these can be stored for up to six months after treating with Captan at 2g/kg of seeds, otherwise these will remain viable only for three months. However, fresh extracted seeds are the best for nursery raising.

Layering

Triploid crossandras do not set seeds hence, can be propagated only through ground layering. Well-conditioned layers can be planted from June to July in pits of 15 × 15 × 15 cm at a spacing of 90 × 90 cm. About 12,500 layers are needed to cover one-hectare. Plants will start flowering within a month of planting.

Softwood tip cuttings

Cuttings of 5–8 cm length are taken during March–June when day and night temperatures are 29°C and 21°C respectively and light intensity is 1500–1800 foot-candle

NOTES

(fc), treated with some rooting hormone and planted in 6.5 cm pots or directly under mist, where rooting occurs in 3–4 weeks, and these, in fact, are called liners. During summer, white plastic tents should be used.

Triploids are also commercially multiplied only through cuttings which are transplanted when sufficient roots have developed. For better results, rooting hormone IBA at 3000 ppm can be used.

Micropropagation

Propagation by cutting has lower rates of multiplication and hence these are multiplied through micropropagation. Multiple shoots from shoot tips have been regenerated on full-strength MS medium fortified with BAP 1 mg/l. Callus induction from leaf bits has been reported on full MS medium fortified with 2,4-D 1 mg+BAP 0.5mg/1.

Preparation of land

The land is thoroughly ploughed twice or thrice after mixing about 25 tonnes of FYM in the soil at the time of first ploughing, all the foreign materials are taken out, field is levelled, and beds of convenient sizes are made with proper provision of bunds for walking and trenches for watering.

Sowing of seeds

Seeds are sown at the rate of 2.0–2.5 kg/ha in the nursery beds in June–July on 10 cm raised beds having 1 metre width or in polythene bags, and lightly covered with 3 mm of medium. Temperatures at this time being 26°C day and 21°C at night are quite congenial and there these germinate within 3–4 weeks though optimum temperature range for better growth is considered 18–20°C. Cabaryl 15% dusting of the seed-sown beds will protect the seedlings against cutworm infestation in the nursery beds.

Planting and Transplanting

Thirty days old seedlings are transplanted in the prepared field when these attain 4–5 leaf stage in the nursery. For better growth cum development along with

higher flower yield, these should be planted with proper spacing. Spacing of a plant depends on the growth and spread of a variety, though commonly, those having normal spread at 50 × 30 cm spacing while others with more spread at 60 × 40 cm distances, where in the former case some 66,666 seedlings per hectare are accommodated, though in latter case some 41,667 plants are grown. Latter spacing is being practiced in Andhra Pradesh. However, the spacing of 45 × 30 cm is recommended for rooted cuttings of cv. 'Delhi'. In yellow crossandra, the spacing followed is 90 × 90 cm. For pot culture, as is being done in Denmark, seedlings and cuttings are transplanted into 6.25 cm pots singly, and the liners which are transplanted into 10 cm, 11 cm or 15 cm pots with final spacing of 16.5 × 18.0, 18.0 × 118.0 or 23.0 × 23.0 cm respectively, are kept pot-to-pot, commercially, until shipped.

Weeding

Weeding, application of manure, fertilisers and earthing up are combined for easy upkeep of crop and labour saving. Application of Metachlor 1.25 kg per hectare can control weed population. Mulching can be done to check weeds and to save water.

Pinching and pruning

Pinching is an important practice in crossandra to make the plant bushy with more axillary branches. In Denmark, under greenhouse conditions, pinching of *Crossandra infundibuliformis* cv. Mona Wallhead is carried out four weeks after planting, leaving three pairs of leaves, to induce more lateral shoots so that inflorescence numbers are increased. Pinching in crossandra is carried out three weeks after the final potting so that 5–6 leaves remain on the plants. However, disbudding is not required in this crop. Pruning of crossandra is carried out to improve plant vigour and flower quality. Light pruning is followed in late winter, after flowering. Once the seeds are formed and reach the advanced stage of development, growth and flowering decline. When the flowering is over, the spent spikes are removed regularly.

Nutrition

For increased growth and flowering in crossandra, application of farmyard manure 25 t/ha is needed. Application of 25 kg N, 20 kg P_2O_5, and 75 kg K_2O per hectare per year is sufficient for this crop. Entire P and K are applied in the field before planting. After the cuttings have rooted, a high dose of nutrient is required for good vegetative growth. A complete liquid fertiliser with 200 ppm N should be regularly provided. In Andhra Pradesh, they recommend FYM 25 t/ha + 5 t/ha neem cake, 38 kg N, 62 kg of P_2O_5, and 62 kg of K_2O/ha. Nitrogen should be applied in two split doses — 60 days and 120 days after planting. Fe, Mn, and Mg being critical nutrients should also be applied. Foliar application of $ZnSO_4$ at the rate of 0.5% once in 60 days is recommended for better quality flowers.

Fe deficiency is a common problem in crossandra. In fact, Fe fertilisation interferes with P nutrition while it does not affect K and Ca nutrition. Foliar application of 1% Fe_2SO_4 + 2% urea is recommended once in every 30 days. Application of 100% NPK + *Azospirillum* + phosphobacteria (41.72 g/plant) increases flower yield with maximum returns. Twenty five per cent reduced rate of application of inorganic nutrients is sufficient if applied along with *Azospirillum* to get yield on par with blanket recommendation of inorganic fertilisers in crossandra.

Irrigation

Crossandra needs adequate moisture in soil immediately after planting. It requires irrigation once in 4–5 days. Crossandra is drought tolerant but requires free watering (for a better yield), there should not be water scarcity at the time when the plants are flowering. But over-watering is detrimental due to the root being susceptible to *Rhizoctonia* whereas starved watering burns the leaves.

Harvesting

Crossandra commences flowering 70–75 days after planting and continues to flower throughout the year

with a drop in production during the rainy season. Flowers start appearing from the base of the spike, and at the same time, two diagonally opposite flowers open on the plant and it takes about two days for complete opening. Flowers are harvested on alternate days in the early morning by pulling corolla out of the calyx. The flowers are ethylene sensitive. After flowering is over, dried spikes are removed.

For local market, flowers are packed in cloth or polythene bags. Its potted flowering plants can be transported under ethylene-free atmosphere at 10–13°C temperature, as temperatures higher than 18°C are damaging and lower than 6°C blacken the leaves. If 1000 foot-candle (fc) light is being provided, a flowering crossandra plant will last up to one month, though ethylene is damaging, causing buds to abscise, so 0.4–0.5 mM STS can be used to negate its effect and to prolong the flower longevity.

Yield of flowers depends on the fertility status of soil, cultural operations, variety, and climate of the area. There is a drop in the production during the rainy season. With a plant population of 40,000 per hectare with spacing of 50 × 50 cm, a yield of 4.5 tonnes per hectare can be obtained. 'Delhi' crossandra yields 6–7 tonnes per hectare. However, the high yielding cultivars may yield up to 7–9 tonnes per hectare. Crossandra flowers are very light and on an average about 15,000 flowers make one kilogram. The crop can be retained in the field for about three years after which it has to be removed as it becomes uneconomical.

While fully opened flowers may remain fresh for about three days on the plants, the harvested flowers will fade within two days; though soaking flowers in 0.5% boric acid or in 1% aluminium sulphate can extend their shelf life by three more hours. Freshly harvested flowers can be packed in cloth or polythene bags for local market.

Insect-pests

Colonies of nymphs and mature females of scales [(brown scale, *Saissetia nigra*; white scale, *Orthezia insignis*); *Saissalia viridis*] infest the leaves, stems, and flowers. They feed on sap and excrete honeydew, which

makes plants sticky, and encourages the growth of sooty moulds. Application of Malathion at 0.3–0.6 kg a.i./ha kills the scale insects.

Adults and eggs of whitefly (*Lipaleyrodes* sp.) infest on the underside of the leaves and the upper surfaces are often fouled with a sticky honeydew and sooty moulds, *vis-à-vis* leaf chlorosis. Infestation reduces the plant vigour, while sooty moulds make the plants unsightly. Yellow spots and other discolourations develop on the leaves. Contact insecticide, Malathion at 0.5/ha or systemic insecticides such as dimethoate at 0.4 kg/ha at weekly intervals will be quite effective.

Sorghum midge *(Contarinia maculipennis)*

It is a small fly which lays eggs within the floral buds. After hatching, orange crawling maggots start feeding developing buds and ovaries causing the failure of bud opening, their rotting in severe cases and pupating therein. The nymphs and adults of pentomid bug (*Gynencia affinis*) infest the shoots and flowers during winter causing brown lesions on the infested parts. Control measures for both the pests are the same as for the white fly. Spider mites and aphids can also cause problems in crossandra cultivation, especially under greenhouse. Mites have also been found infesting the crossandras in Andhra Pradesh which can be controlled through an effective miticide, viz., Kelthane at 25 EC mi/l.

Nematodes

Commonly infesting on crossandra, the nematodes are *Meloidogyne incognita, M. arenaria, M. javanica* (all root-knot nematodes), *Pratylenchus delattrei* (lesion nematode), and *Longidorus africanus* (needle nematode). The roots exhibit brown to black lesions and prominent galls. The needle nematode causes forking and clubbing of the root tips. It causes chlorotic leaves which ultimately turn white at the advanced stage of infestation. In case of severe attack, plants become stunted without any side shoots and remain defoliated. Application of Phorate at 1g/plant weekly, after planting, checks the nematodes.

Diseases

Wilt

In crossandra, wilt is caused by *Phytophthora* spp. and *Fusarium solani* whose infection is expressed as paling of the leaves with pinkish-brown margins, followed by drooping. Discolouration may extend up to the midrib within 7–10 days. Stems also shrivel and the dark lesions can be seen on the roots extending to the collar region, and at this time, the invasion by *Pratylenchus* nematodes will predispose the plants to the fungus, causing severe wilting. To get rid of this problem, the crossandras must not be grown in nematode infested soils; however, nematodes can be controlled by soil application of Phorate at 1 g/plant after 10 days of transplanting. Crop rotation with marigold will also reduce nematode population in the field. Soil drenching with carbendasim 0.1% or copper oxychloride 0.25% at 30 days interval will control the disease effectively. Pulling and destroying the infected plants will also minimise the disease occurrence. Application of *Trichoderma viride* and *T. harzianum* cultured in FYM or on neem cake before transplanting effectively reduces the incidence of *Fusarium oxysporum*.

Collar rot *(Sclerotium rolfsii)*

It occurs in the soil as the pathogen is soil-borne, so usually infects the plants at the time of transplanting. It causes brown and sunken spots on the bark of the collar region which later on extends to the roots and its brown to black discolouration is seen after the peeling of such barks. The leaves of the infected plants show pink discolouration and fall off. Seedling root dip with 0.1% thiram and in a mixture of *Pseudomonas* sp. + *Trichoderma viride* will control this problem.

Stem rot

It occurs in the form of pre-emergence damping off through rotting of the stems and roots. Brown to black lesions develop on the stem just above the soil level and girdle the stem. Lesions extend to the upper part of the stem and result in the collapse of seedlings. Fortnightly

Notes

spraying of benomyl at 0.2% and Captan at 0.25% at early stage of infection controls the disease.

Root and Crown rot

It is caused by *Phytophthora nicotianae*, the soil-borne pathogen, which enters the plants through damaged tissues. It causes violet discolouration of leaves and the basal regions of plants rot. It is better to destroy the affected plants.

Black root rot (*Rhizoctonia spp. and Thielaviopsis spp.)*

It may be a serious problem during and after propagation, so deep planting should not be followed to avoid incidence including that of its *Pythium*.

Flower rot

It is caused by *Fusarium pallidoroseum* where the leaves turn purplish, most prominently on the veins, the internodes become shortened and flowers decay with cottony colonies of the fungus. These symptoms begin on the older leaves and extend upward into the younger leaves towards the apical branches. The branchlets also turn purple.

Leaf blight

It is caused by *Colletotrichum crossandrae,* and in its infection, the leaf margins are slightly rolled up with brownish to reddish and depressed necrotic areas, more prominently on the lower leaves and that too near the margins. Such leaves shrivel and drop off leaving a whorl of young leaves only at the top. Proper sanitation, removal of affected parts, sulphur spraying at 7–10 days interval at its first appearance, and spraying with 0.1% benomyl, carbendazim, or 0.2% mancozeb will control this malady effectively.

Practical Exercise

Activity 1

Demonstrate the ground layering in Crossandra.

Material required

Knife, stone piece, hook, or pegs, polythene bags, secateurs, matchstick.

Procedure

- Select the flexible branches which can reach the ground level.
- Bend down the flexible branch.
- Make a 2 cm slit with the help of a knife under the node.
- Insert a matchstick in the slit.
- Remove the leaves of the portion that goes underground.
- Place the operated portion (slit-tongue) below the soil.
- Follow the recommended practices for nutrition and irrigation to the mother plant.
- Layered plant is detached after the formation of sufficient roots.
- Layered plant is placed in a polythene bag with the soil mixure for growing.
- Light irrigation is provided to the new plant.

Check Your Progress

A. Fill in the Blanks

1. Crossandra is commonly known as _____.
2. A high yielding variety of crossandra is _____.
3. Seed rate of crossandra is _____ per hectare.
4. Triploid crossandras can be propagated by _____.
5. Crossandra commences flowering after _____ days of planting.
6. Crossandra flowers are _____ sensitive.

B. Multiple Choice Questions

1. Crossandra belongs to _____ family.
   (a) Asteraceae (b) Rosaceae
   (c) Acanthaceae (d) Irridaceae
2. Among the following, which one is the native place of Crossandra?
   (a) Asia (b) Europe
   (c) Australia (d) Mexico
3. Which of the following climate is suitable for crossandra growing?
   (a) Temperate (b) Tropical
   (c) Sub-tropical (d) All the above
4. Mona Wallhead variety of Crossandra was introduced in India from which country?
   (a) USA (b) Brazil
   (c) Sweden (d) Sri Lanka

5. Crossandra is planted at spacing of _____.
   (a) 20 × 20 cm (b) 30 × 30 cm
   (c) 50 × 50 cm (d) 75 × 75 cm
6. Shelf life of Crossandra flower is _____.
   (a) 2–3 days (b) 5–6 days
   (c) 7–8 days (d) 9–10 days

C. Subjective questions

1. What is the importance of the crossandra flower?

   _____
   _____
   _____
   _____

2. How is propagation of crossandra done through seeds?

   _____
   _____
   _____
   _____

3. How is ground layering done in crossandra?

   _____
   _____
   _____
   _____

4. How is planting of crossandra done?

   _____
   _____
   _____
   _____

5. Describe flower harvesting of crossandra.

   _____
   _____
   _____
   _____

D. Match the Columns

A	B
1. Kanakadhara	(a) A leaf-variegated mutant
2. Raj Kanakambaram	(b) Chemical mutagenesis (sodium azide)
3. Subasu	(c) Gamma irradiation
4. Neelambari	(d) Dense green foliage
5. Dr. A.P.J. Abdul Kalam	(e) Long inflorescences

Unit 3

Growing of Annuals

The landscape design, lawns, flowering annuals, foliage plants, shrubs, trees, and other plants and features are of fundamental importance in a garden. No garden seems to be complete until it has beds of ornamental annual flowering plants. Introduction of annual flowering plants adds immensely to the decorative value of the garden whether it is large, small, public, or a private garden.

Annuals are defined as those monocarpic plants that complete their life cycle within a season or year from seed to seed. They complete the process of their life cycle such as germination, growth, flowering, seed formation, and natural death in a season or a year. They need fresh planting or sowing in every season or year. They are generally herbaceous and hardy to semi-hardy, for example antirrhinum, China aster, gomphrena, marigold, petunia, verbena, zinnia, etc.

Annuals provide a beautiful look of various colours in the garden. These plants mostly have a long flowering duration, sizeable height coupled with a wide colour range, ease of cultivation, attractive shape, and general adaptability. In addition, many annuals such

as acroclinium, ammobium, antirrhinum, calendula, carnation, China aster, helichrysum, larkspur, etc., produce excellent cut flowers, some such as acroclinium, helichrysum, nigella, statice, etc. are used as dry flowers, while annual chrysanthemum, gaillardia, marigold, etc., are used as loose flowers.

Selection of flowering annuals and their varieties for commercial cultivation should be proper as per the soils, climatic conditions, available resources, consumer choice, market demand, and availability. Raising of healthy seedlings of annuals in pro-tray, polythene bags, and small seed packets has good commercial scope.

The important annuals are *Amberboa moschata* (*Centaurea moschata*; Sweet Sultan), *Antirrhinum majus* (dog flower/snapdragon), *Arctotis breviscapa* (African daisy/blue-eyed daisy/Transvaal daisy), *Bassia scoparia* (*Kochia scoparia*; burning bush/summer cypress), *Bracteantha bracteatum* (*Helichrysum bracteatum*; everlasting flower/immortelle/straw flower), *Calendula officinalis* (*Calendula*/scotch marigold), *Callistephus chinensis* (China aster), *Celosia argentea* (Cock's comb/wool flower), *Centaurea cyanus* (Cornflower/blue bottle), *Chrysanthemum carinatum* (Annual chrysanthemum), *C. coronarium* (Crown daisy), *Coreopsis tinctoria* (Tickseed), *Dianthus barbatus* (Sweet William), *Dimorphotheca pluvialis* (*D. annua*; sun marigold/weather prophet), *Eschscholzia caespitosa* (Tufted California poppy), *E. californica* (California poppy), *Gaillardia pulchella* (Blanket flower/fire wheels/Indian blanket), *Gomphrena globosa* (Batchelor's buttons/globe amaranth), *Gypsophila elegans* (Baby's breath), *Iberis amara* (Candytuft), *Impatiens balsamina* (Balsam), *Lathyrus odoratus* (Sweet pea), *Limonium sinuatum* (Statice), *Linum grandiflorum* (Flowering flax), *Salvia splendens* (Scarlet sage), *Phlox drummondii* (Phlox), *Lobularia maritima* (*Alyssum maritimum;* Sweet alyssum), *Lupinus subcarnosus* (Texas bluebonnet), *Petunia hybrida* (Petunia), *Matthiola incana* (Brompton stock/gillyflower), *Papaver commutatum* (Poppy), *P. rhoeas* (Corn poppy/field poppy/flanders poppy), *P. somniferum* (Opium poppy), *Tagetes erecta* (African marigold), *T.*

patula (French marigold), *Tropaeolum majus* (Indian cress/nasturtium), *Verbena hybrida* (Verbain), *Viola wittrockiana* (Pansy), *Dianthus chinensis* (Indian pink), *Eschscholtzia californica* (Californian poppy) and *Zinnia elegans* (Zinnia).

Importance of Annuals

- They are used as instant landscaping for decoration on various occasions.
- They can be grown individually or with plants in borders or in beds.
- They can be trained on walls and trellises.
- They can be planted in the form of edges, borders, or ground covers.
- They can be grown for cut flowers, loose flowers, and dried flowers.
- They can be planted in hanging baskets and pots.
- They are also suitable for planting in rock gardens.

Classification of Annuals

Based on Season

Winter season annuals

These are grown in the winter season, and can withstand low temperature and low humidity. The seeds of these annuals are sown in September and transplanted in October, for example *Amberboa moschata* (Sweet sultan), *Antirrhinum majus* (Snapdragon), *Consolida ajacis* (Larkspur), *Iberis amara* (Candytuft), *Petunia hybrida*, *Phlox drummondii*, *Tropaeolum majus* (Nasturtium), *Verbena hybrida*, *Viola wittrockiana* (Pansy), etc.

Summer season annuals

These annual plants are grown in the summer season. These can tolerate high temperature and dry weather to produce flowers. The seeds are sown in the end of February or beginning of March, and seedlings are transplanted after 25–30 days. These are *Bassia scoparia* (Kochia), *Cosmos bipinnatus* (Cosmos), *Gaillardia pulchella* (Blanket flower), *Gomphrena globosa* (Globe

amaranth), *Helianthus annuus* (Sunflower), *Portulaca grandiflora* (Moss rose/purslane), *Tithonia rotundifolia* (Mexican sunflower), *Zinnia elegans*, etc.

Rainy season annuals

These are grown in rainy season, and can produce flowers under high humidity and rainfall as compared to other annuals. Seeds are sown in June and seedlings are transplanted in July. Such annuals are *Amaranthus caudatus* (Love-lies-bleeding/rassel flower/Velvet flower), *Gaillardia pulchella* (Blanket flower), *Impatiens balsamina* (Balsam/busy lizzie/patience plant), *Celosia argentea* (Cock's comb/wool flower), etc.

Based on purpose and/or place

Purpose	Annuals
Rockery	Ageratum, Alyssum, Brachycome, Gamolepis, Linum, Nemesia, Phlox, Portulaca, Saponaria, etc.
Hanging basket	Impatiens, Petunia, Phlox, etc.
Foliage plants	Amaranthus, Kochia, etc.
Edge plants	Dwarf Ageratum, Alyssum, Brachycome, Dianthus, Nigella, Pansy, Portulaca, etc.
Fragrant flowers	Carnation, Stock, Sweet pea, Viola, etc.
Bedding plants	Balsam, Candytuft, Carnation, Ice Plant, Marigold, Pansy, Petunia, Phlox, Verbena, etc.
Dry flowers	Acroclinum, Annual Chrysanthemum, Helichrysum, Limonium, Nigella, etc.
Pot plants	Antirrhinum, Carnation, China aster, Linum, Petunia, etc.
For shady situation	Cineraria, Salvia, Torenia, etc.
For screening	Hollyhock, Quamoclit, Sweet pea, etc.
Cut flowers	Antirrhinum, Calendula, Carnation, Celosia, China aster, Cornflower, Gypsophila, Larkspur, Stock, etc.
Loose flowers	Annual chrysanthemum, Gaillardia, Gomphrena, Marigold, Zinnia, etc.

Fig. 3.1: Pot marigold (Calendula officinalis)

Fig. 3.2: Carnation (Dianthus Caryophyllus)

Fig. 3.3: Indian pink (Dianthus chinensis)

Fig. 3.4: Californian poppy (Eschscholtzia californica)

Fig. 3.5: Ice plant (Mesembryanthemum crystallinum)

Fig. 3.6: Petunia (Petunia hybrida)

Fig. 3.7: Phlox (Phlox drummondii)

Fig. 3.8: Sweet pea (Lathyrus odoratus)

Fig. 3.9: Verbena (Verbena officinalis)

Fig. 3.10: Hollyhock (Rosea)

Fig. 3.11: Antirrhinum (Antirrhinum majus)

Fig. 3.12: Gomphrena (Gomphrena globosa)

Fig. 3.13: Zinnia (Zinnia elegans)

Fig. 3.14: Larkspur (Delphinium ajacis L.)

Herbaceous Border

The planting of annuals in the border of a bed in a definite pattern is known as herbaceous border. Its length is much more than the width and maybe made against a wall, fence, shrubbery, hedge, or a path. It maybe single or double-faced. Single faced border is viewed from the front side whereas double-faced is created in the centre of the garden so that it can be viewed from both the sides.

The ideal site for making a herbaceous border should be sunny and facing South so that the annuals get sunlight for the maximum duration in a day. If that direction is not available, it should be made facing the East direction. Here, tall annuals are planted in the back, the intermediate types in the centre, and the smallest ones in the front in single-faced border; while in the double-faced border, the tallest ones are kept in the centre, then the intermediate types at both the sides, and in front of both the sides the smallest ones are kept. The width of single-faced border is about 2.5 metres while that of the double-faced ones is roughly 4.5 metres.

Cultivation of Common Annuals

Preparation of seedbed

- Seeds of annuals are sown on a raised seedbed.
- The soil should be sandy loam, rich in organic matter, and well-drained.
- Soil pH should range between 6.0 and 7.5.

- The soil of the seedbed should be deeply cultivated to bring it to a fine tilth and all the stumps, weeds, stones, brick, tile pieces, and wood pieces, etc., should be removed from the field, and land should be levelled.
- Soil of the bed should be sterilised before sowing, to prevent diseases such as damping off.
- The sterilisation may be done after mixing 5–10 kg of FYM/m^2, with 2% formalin through soil drenching, to kill the pathogenic spores and nematodes in the soil, covered with polythene at least for 48 hours, then the soil is exposed for about a week, and then the sowing is carried out after levelling the bed.
- Nursery beds of any convenient length, but of 1.5 metre width and 15–20 cm raised are prepared.
- In between two beds, a space of 30–40 cm is left for performing various operations.

Seed sowing in beds

Seeds of the annuals are sown in nursery beds or in plug trays. However, annuals, which have bold seeds like sweet pea, nasturtium, lupin, etc., or seeds, which are difficult to transplant like linaria and eschscholzia, are sown directly. Seeds should be sown 2–3 cm apart in rows that are spaced 5–10 cm apart, which facilitates easy weeding, drenching, and removal of disease-infected seedlings.

- The surface of the bed is levelled using a fork or wooden plank.
- Straight lines are made across the bed at a spacing of 5 cm and 0.5–1.0 cm deep. Time of the seed emergence depends on the depth to which the seeds have been sown. If it is too shallow, the seeds come up and dry out early but if it is too deep, the emergence of seedling takes more time. Seeds are sown approximately at a depth of 2–3 times the diameter of the seed.
- Small seeds are mixed with bulk material like ash or sand for an even distribution.
- The seeds are then covered with a mixture of 0.5 cm of fine soil, sand, well rotten and sieved FYM in the ratio of 2:1:1.

- Spraying the seed covering mixture with 0.25% Captan protects the seedlings from damping off disease.
- Mulching seedbeds by polyethylene sheet or paddy straw helps in the quick and uniform germination of seeds.
- When seedlings initiate emerging, the mulch should immediately be removed carefully in the evening hours.
- The beds require light irrigation from sowing up to transplanting by the means of a rose can daily by the evening.

Seed sowing in plug trays

These days, high value annual seeds are preferred to be sown in plug trays, commonly called as pro-trays instead of nursery beds. Pro-trays have shallow plugs. In these trays, used germination media remain warm and provide better aeration especially during germination. Seeds can be sown directly into these plugs trays. Weeding and thinning operations are also easily carried out in these pro-trays. Seedlings are removed easily without any damage to its roots. The steps involved are as follows:

- annual seeds are now commonly sown in a pro-tray with cocopeat, vermiculite or sand;
- the pro-trays are filled with medium and one seed is sown per cell. Small depressions (0.5 cm) are made at the centre of the plugs with finger tips for sowing of seed;
- the seed is then covered with medium;
- ten pro-trays are arranged one by one and covered by a polythene sheet, and kept as such for four to five days or till germination starts;
- after five or six days, the polythene cover is taken out and fertigation is sprinkled by a rose can.

Transplanting of seedlings

Transplanting is a process in which seedlings or rooted cuttings are planted from one open place, that is,

nursery beds, pro-trays, pots, etc., to their permanent site for further growth and flowering.

- Seedlings should have attained proper age and stage of transplanting.
- They should be sturdy.
- They should have a well-developed root system.
- They must be vigorous and healthy.

Method of transplanting

- Transplanting should be done when the seedlings are about four weeks old or have formed about three to four true leaves.
- The nursery bed is watered 24–48 hours before transplanting and then the water should be withheld to harden the seedlings.
- Transplanting should be performed in the evening so that the plants may establish themselves in the night.
- From the nursery, the seedlings should be lifted by digging them up gently and not being pulled up.
- Immediately after transplanting, the transplants are watered so that they do not have transplanting shock and recover fully.
- Tall grown seedlings should not be transplanted as they are weak and may start flowering very early.
- Transplanting is done on a land which should be well prepared by ploughing and incorporating 5 kg well rotten FYM along with 10g each of N, P_2O_5, and K_2O per square metre.
- Frequent sprinkling of water on the newly transplanted seedling may cause wilting.
- The soil near the root zone should be pressed properly after transplanting.
- Depth of transplanting should accommodate the complete root system.

Annuals are planted as follows

Height	Spacing (cm)
Tall annuals	60×60
Medium annuals	45×45
Dwarf annuals	30×30

Application of manures and fertilisers

- Supply of nutrients along with organic manure greatly improves the physical condition of the soil.
- FYM and compost are easily available organic manures.
- In the field, wellrotten manure must be applied well before planting of seedlings.
- In new transplanted seedlings, chemical fertilisers should be used in small amounts.
- A mixture of both chemical fertilisers and organic manure in low concentration must be used in the form of solution during the vegetative phase of the plants to get good vegetative growth along with increased quality and quantity of flowers.
- Before laying out the plan, land should be well prepared by ploughing and mixing 5 kg wellrotten FYM and 10 g each of N, P_2O_5, and K_2O per sq. m. through 40 g calcium ammonium nitrate, 62 g single superphosphate and 16 g of muriate of potash.
- Vermicompost is an emerging manure, which is effective in much smaller quantity than that of FYM and compost.

Irrigation method

Prevailing weather conditions, water infiltration rate in the soil, age and vigour of the plant are the main factors which decide the amount of water required by the plants at any given time. At the time of germination, frequent light watering is required to keep the seedbeds moist, to facilitate germination. As plants become large, the total quantity of water required is increased and the frequency of application is reduced. During summer, watering is done weekly but during the winter season at an internal of 10–12 days interval.

Irrigation is required to

- increase the absorption of nutrients from the soil,
- replace loss of water caused due to transpiration,
- maintain turgor pressure in the plants,
- increase the photosynthesis rate.

Method of watering in nurseries

- Watering is done either by hand or through the micro-irrigation system. In small area and/or nurseries, hand watering by rose cans, hose pipes fitted with spray-nozzles, or knapsack sprayers are commonly used.
- In watering of seedbeds, a fine droplet size is very essential, otherwise, the seeds may be washed out or the seed covering material maybe washed away.

General rules for irrigation

- Irrigation should be done before the water stress symptoms occur.
- Irrigation should be done under cooler conditions.
- Water should be applied on the soil surface and not on the plants. This helps to reduce the risk of many diseases.
- Water must be given according to the seasonal requirement of the plant.

Cultural operations

Weeding

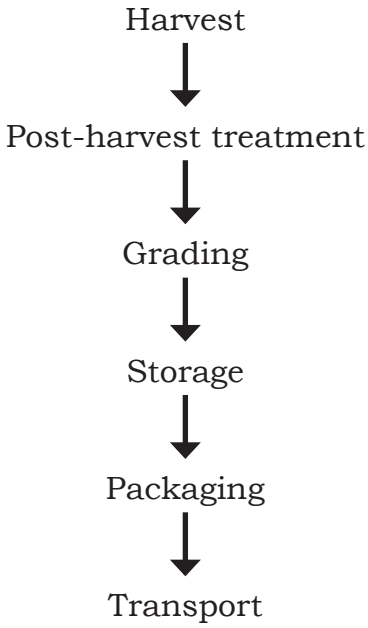
Regular weeding and hoeing are essential for developing healthy plants. Weeding is carried out physically with the help of a *khurpi* or hand hoe.

Irrigating annuals

- Little amount of water is needed everyday for up to 7–10 days, starting just after transplantation.
- When the seedlings start new growth, the beds should be watered once or twice a week, profusely.
- Irrigation in beds during summer should be carried out at 5–7 days' intervals.
- In the winter, irrigation is done at 10–12 days intervals.
- In the rainy season, it solely depends on the weather conditions.
- Potted plants require daily but little watering during the summer, whereas on alternate days in winters.
- Over-irrigation should never be done.

Harvesting and post-harvest operations

Cut flower annuals require proper post-harvest management for prolonging their vase-life. The stages after cultivation of annuals involve:



Harvesting

- Though annuals are grown in gardens or pots for instant display, but these are also grown for plucking flowers or for cutting for sale.
- Harvesting is normally done by hand using shears or a sharp knife.
- In general, the flowers are cut either late in the afternoon or very early in the morning. Flowers should always be harvested at the right maturity stage.
- Prematurely harvested flowers will never come to a full bloom.
- Most of the flowers are harvested when they are fully open, for sale in the local markets.

Post-harvest handling

- Immediately after harvesting, flowers should be kept in a bucket having demineralised water up to one-fourth the volume of the bucket as it helps in their recovery from the shock inflicted through the cutting from the parent plant.

- Flowers are placed as quickly as possible in the post-harvest treatment solutions like aluminium sulphate and a special wetting agent.
- For most flowers, the time between cutting and placing on the solution should be no longer than half an hour.
- As most flowers are susceptible to Botrytis infection, so great care has to be taken to prevent its infection.
- By using clean buckets, clean water, and the right post-harvest treatment, the chance of infection can be minimised.

Storage

- If flowers are not sold the day they are harvested, they have to be stored in cold storage for a specific duration until their packing and transportation.
- The flowers have to be cooled down to their optimum storage temperature.

Storage temperature recommendations and approximate storage life of some annuals are given as under:

Annuals	Storage temperature (°C)	Storage life (approx.)	Vase life
China Aster	0 to 4	1 to 3 weeks	5 to 10 days
Clarkia	4	3 days	5 to 10 days
Cornflower	4	3 days	6 to 10 days
Cosmos	4	3 to 4 days	4 to 6 days
Dahlia (bedding type)	4	3 to 5 days	7 to 14 days
Delphinium	4	1 to 2 days	4 to 12 days
Gypsophila	4	1 to 3 weeks	5 to 10 days
Phlox	4	1 to 3 days	2 to 7 days
Snapdragon	4	1 to 2 weeks	5 to 7 days
Statice	2 to 4	3 to 4 weeks	4 to 8 days
Stock	4	3 to 5 days	5 to 8 days
Sweet pea	0.5 to 0	2 weeks	3 to 7 days
Sweet William	7	3 to 4 days	5 to 9 days

Packaging

- Proper packaging is essential to check the spoilage of flowers.

- The packing material should be economical but sturdy, and able to protect the flowers during transportation. The materials that are generally used in India for construction of a package are bamboo, wood, gunny bags, plastic films, corrugated fibre boards, and newspaper for precision harvest.

Insect-pests and disease management

Sucking pests

Thrips, aphids, and hoppers infest the annuals in nursery and field. These can be effectively controlled by spraying insecticides like dimethoate 2 ml/litre.

Caterpillars

These infest the annuals at flowering and the seed formation stage. These are effectively controlled by spraying spinosad at 0.5 ml/litre.

Damping off

This malady occurs usually at the nursery stage when the seed is sown too densely. The rot occurs at the collar stage of the seedlings. It can be controlled by spraying copper oxychloride at 2–3 g/litre.

Safety precautions

1. Wearing of an apron, gloves, face mask, boots, etc., while handling the seeds, insecticides, fungicides, and weedicides.
2. Seeds, pesticides, and equipment should be kept away from the reach of children.
3. In case of any accidental hazard, a doctor should be consulted immediately.

Practical Exercise

Activity 1

Raising of annuals' seedlings

Material required

Seeds of annuals, watering can, measuring tape, *khurpi*, sand, notebook, small size demarcation board, etc.

Procedure

- Prepare raised nursery bed in a protected place, keeping the upper 5 cm surface fine with adding of well decomposed FYM or vermicompost.

- Select the annuals as per the purpose for which they are being grown.
- Calculate the quantity of seeds as per the required plant population.
- Treat the seeds with carbendazim at 2 g/kg followed by chlorpyriphos at 5 ml/kg of seed before sowing.
- Sow the seeds in prepared raised beds and cover the seeds with fine soil, sand, or leaf mould. When the seeds are sown in a seed pan, a pot mixture consisting of two parts of soil, two parts of well rotted leaf mould, and one part of sand should be used.
- Fine seeds may be mixed with three to four parts of sand before sowing.
- Watering the nursery maybe done with a rose can. After complete seed germination, crowded seedlings are thinned out.
- Recommended fungicide or insecticide is sprayed on seven days old seedlings. Nursery beds should be kept moist by regular sprinkling of water.
- One month after planting, when the seedlings have produced six to eight leaves, they can be lifted safely with the help of a *khurpi* and kept in moist jute bag or polyethylene bags at a shaded place, and then transplanted into the main bed.

Check Your Progress

A. Fill in the Blanks

1. Plants that complete their life cycle within a season or in a year are _____.
2. Low temperature can be withstood by _____ annuals.
3. Winter annuals can be sown in _____.
4. High temperature and dry weather can be tolerated by the_____ annuals.
5. High humidity is required for the flowering of _____ annuals.
6. Rainy season annuals can be sown in _____.
7. The planting of annuals at the border of a bed in a definite pattern is known as _____.
8. Artificial application of water to the crop is known as _____.
9. A serious disease of nursery is _____.
10. Plug trays are commonly known as _____.

B. Multiple Choice Questions

1. The width of single-faced border is kept at about _____.
   (a) 2.5 m
   (b) 4.5 m
   (c) 5.5 m
   (d) 6.5 m

2. The width of double-faced border is kept at about _____.
   (a) 2.5 m
   (b) 4.5 m
   (c) 5.5 m
   (d) 6.5 m
3. Which of the following is not a winter season annual?
   (a) Candytuft
   (b) Pansy
   (c) Zinnia
   (d) Sweet sultan
4. Tall annuals are generally planted at a spacing of _____.
   (a) 20 × 20 cm
   (b) 30 × 30 cm
   (c) 40 × 40 cm
   (d) 60 × 60 cm
5. Storage temperature of dahlia flower is about?
   (a) $0^{\circ}C$
   (b) $2^{\circ}C$
   (c) $4^{\circ}C$
   (d) $46^{\circ}C$
6. Which of the following is a rainy season foliage annual?
   (a) Gaillardia
   (b) Petunia
   (c) Larkspur
   (d) Kochia

C. Subjective Questions

1. Write about annuals and their importance.

   _____
   _____
   _____

2. Give the important characteristics of annuals.

   _____
   _____
   _____

3. Describe herbaceous border.

   _____
   _____
   _____

4. How is a seed bed prepared for raising annuals?

   _____
   _____
   _____

NOTES

5. How are annuals sown?

_____

_____

_____

6. Write the method of transplanting the seedlings of annuals.

_____

_____

_____

7. What are the general rules for irrigating the annuals?

_____

_____

_____

8. Discuss the classification of annuals.

_____

_____

_____

9. Write about the harvesting and post-harvest handling of annuals.

_____

_____

_____

10. Give any two examples of annuals suitable for planting on or as:
    (a) hanging basket
    (b) edge plants
    (c) pot plants
    (d) cut flowers

D. Match the Columns

A	B
1. Fragrant flowers	(a) Cineraria, Salvia
2. Bedding plants	(b) Antirrhinum, Carnation
3. Dry flowers	(c) Acroclinum, Helichrysum
4. Pot plants	(d) Balsam, Ice Plant
5. For shady situation	(e) Carnation, Stock

Unit 4

Growing of Perennials

Perennial is the group of plants that remains productive for many years and gives economic returns continuously, for years together, when planted once. The cycle of production continues year after year or season after season for more than two years. They live longer, are hardy, and can tolerate adverse climate. If once planted or sown, they are not required to be replanted year after year, for example, Amaltas, Bauhinia, Gardenia, Ixora, Jasmine, Quisqualis, Rose, etc.

171210CH04

Types of Perennials

Perennial Herbs or Herbaceous Perennials

Those perennials which have non-woody, soft and fibrous stem, and where aerial plant parts may dry or rot once in a year during adverse weather conditions, are known as herbaceous perennials, such as Carnation, Chrysanthemum, Gerbera, etc.

Climbers

The group of perennials, which have weak stems and require support to climb or creep, are known as climbers. These cannot stand erect without any support. They have specialised organs like tendrils with which they twine to any support to grow vertically (climber), or

may creep over through haustorium or with the help of hooked thorns as creepers, for example, golden shower, rangoon creeper, bougainvillea, money plant, etc.

Shrubs

These perennials are medium bushy plants growing up to 5 m in height but with base-branching, producing hard and woody stems from the ground level such as rose, allamanda, ixora, mussaenda, gardenia, night jasmine, hibiscus, etc.

Trees

The plants which have well defined single woody stem with branching are called trees. The height may be more than 5 meters. Such plants are gulmohur, kadamba, shirish, acacia, michelia, magnolia, ashok, neem, peltophorum, bauhinia, etc.

Uses of Perennials

1. Trees can be planted on avenues and parkings for shade and beautification.
2. Shrubs can be planted as hedges (for creating boundaries and screening) or in groups and for producing loose flowers.
3. Climbers can be trained to climb on trees, buildings, arches, and pergolas to enhance beauty.
4. Some of the perennials like carnation, chrysanthemum, rose, etc., produce cut flowers.
5. They are used as potted plants for indoor beautification of houses, offices, hospitals, schools, and ceremonies.

Session 1: Trees, Shrubs and Vines

Importance of Trees

Commensurately and proportionately planted trees along the buildings make the buildings more valuable. Their proper placing in the garden enhances the visual effect of the garden, and systematically planting the trees along the road sides, apart from providing shade during harsh summer, also give a very pleasing effect. Trees make for a strong framework in landscaping.

Trees are tall growing perennials, with marked trunk and they bear flowers and fruits for several years, and provide shelter to various animals and birds, and also provide fuel, fodder, and timberwood. They function as natural air conditioners, provide fresh oxygen by absorbing pollutants, are used in preparing various medicines, yield rubber and gums. They also regulate rainfall and check soil erosion and pollution.

Classification of trees

According to uses and/or purpose

Foliage trees

Leaves are evergreen and attractive. Most of them can grow in shade. Some of them grow erect. They exhibit architectural beauty and are most suitable for avenues. Some of the foilage trees are as follows:

1. *Alstonia scholaris* (Devil's tree)
2. *Saraca indica* (Sita Ashok)
3. *Azadirachta indica* (Neem)
4. *Ficus benghalensis* (Banyan)
5. *Polyalthia longifolia* (Ashok)
6. *Samanea saman* (Rain tree)
7. *Pinus longifolia* (Indian pine)
8. *Albizia Lebbeck* (Siris)
9. *Pongamia pinnata* (Karanj)

Fig. 4.1: Sita Ashok (Saraca Indica)

Fig. 4.2: Indian pine (Pinus longifolia)

Fig. 4.3: Siris (Albizia Lebbeck)

Fig. 4.4: Karanj (Pongamia pinnata)

- Shady trees: Neem (*Azadirachta indica*), banyan (*Ficus benghalensis*), rain tree, *Swietenia*, Shisham, Silver Oak, etc.
- Erect growing: Ashok, Semal, Christmas tree, Arjun, etc.

Fig.4.5: Silver oak (Grevillea robusta)

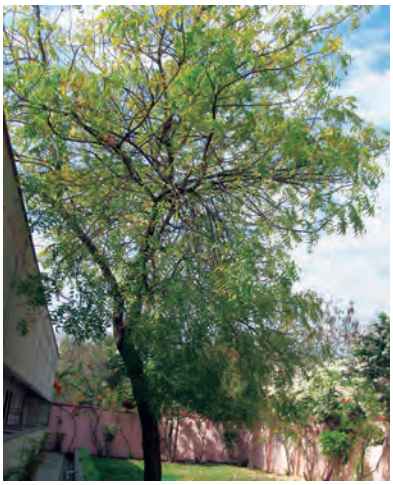


Fig. 4.6: Neem (Aazadirachta indica)

Fig. 4.7: Chrismas tree (Araucaria sp.)

Fig. 4.8: Fountain tree (Spathodea campanulata)

Fig.4.9: Amaltas (Cassia fistula)

Flowering trees

These bear beautiful flowers of different colours in a particular season and beautify the environment. Mostly, these are planted as avenue trees, in gardens and parks, around architectural buildings, along the railway track, on the banks of rivers, etc. These are Cassia species, Bauhinia species, Delonix species, Butea species, *Champa*, Blue Gulmohar, Semal, etc.

1. *Cassia fistula* (Amaltas)
2. *Delonix regia* (Gulmohar)
3. *Jacaranda mimosaefolia* (Blue gulmohar)
4. *Bauhinia purpurea* (Kachnar)
5. *Butea monosperma* (Palas)
6. *Erythrina indica* (Indian coral tree)
7. *Cassia javanica* (Pink Shower)
8. *Spathodea campanulata* (Fountain tree)

Fig.4.10: Pink Shower (Cassia javanica)

Fig.4.11: Kachnar (Bauhinia spp.)

Fig. 4.12: Gulmohar (Delonix regia)

Fig.4.13: Champa (Plumeria sp.)

Fig. 4.14: Palas (Butea monosperma)

Fruit trees

These are grown or cultivated commercially for their delicious and nutritious fruits. These maybe grown in a corner of the garden or near the houses. Such trees are mango, aonla, jamun, tamarind, wood apple, sapota, fig, date palm, coconut, etc.

Medicinal trees

These are the trees grown for their medicinal properties such as Arjun, Bael, Behera, Jamun, Gugul, Neem, Olive, etc.

Fig.4.15: Bottle Brush (Callistemon citrinus)

According to the form of tree (Canopy)

These may have canopy in the shape of round, oval, pyramidal, umbrella type, erect, and weeping or drooping type. Example, Bottle Brush (*Callistemon citrinus*).

According to growth habit

Evergreen trees

These trees show continuous growth. They remain green and do not shed leaves suddenly, hence are called evergreen trees. Such trees are *Dalbergia sissoo, Terminalia arjuna, Polyalthia longifolia, Diospyrus, Saraca indica, Ficus benjamina, Ficus elastica* etc.

Fig. 4.16: Ashoka tree (Polyalthia longifolia)

Fig. 4.17: Weeping fig (Ficus benjamina)

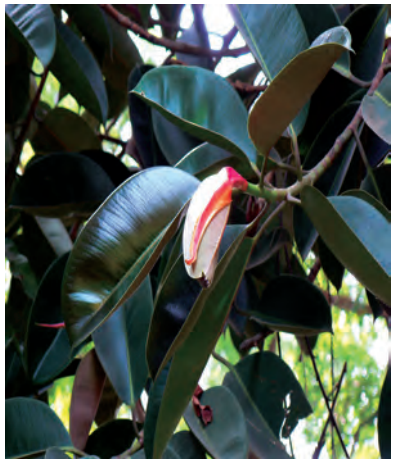


Fig. 4.18: Indian rubber (Ficus elastica)

Deciduous trees

The growth phase is discontinuous. During adverse conditions, each year they undergo a sluggish period when these shed their leaves. When the weather

improves, new leaves start appearing. There are many such trees, such as Banyan (*Ficus benghalensis),* Neem (*Azadirachta indica),* Peepal (*Ficus religiosa).*

Fig. 4.19: Peepal (Ficus religiosa)

Classification of Shrubs According to Use

Shrubs with ornamental foliage

These shrubs are grown for their attractive foliage—brightness (shining), shape, size, colours, texture and variegation, and even some being foetid when crushed. These are used in various features of gardens as hedges, edges, borders, shrubbery, topiary, in pots, etc. Some of such shrubs are *Acalypha*, *Aralia*, *Buxus, Codiaeum*, *Coleus*, *Dodonaea, Dracaena*, *Duranta*, *Euonymus, Lawsonia, Pandanus*, *Putranjiva, Thuja, Golden Juniper* etc.

Fig. 4.20: Golden juniper (Juniperus chinensis)

Fig. 4.21: Thuja (Thuja orientalis)

Flowering shrubs

These shrubs are grown for their shape, size, texture, fragrance, and attractive flowers. They are planted as specimen plants, in pots and bowls, at entrance, in shrubbery border, against the walls, for mass effects in the garden, for making topiary, hedges and knot gardens, and to demarcate one feature of the garden from the other. Some of such shrubs are *Bougainvillea, Cassia, Daedalacanthus, Euphorbia*, *Gmelina, Hibiscus mutabilis, H. rosa-sinensis*, *H. syriacus, Ixora*, *Jasminum*, *Lantana*, *Nerium oleander*, *Rosa*, Peacock Flower, Red powder puff, Night queen, Scarlet bush, Kamini, Mussaenda, Chandani, Tecoma, etc.

Fig. 4.22: Peacock Flower (Caesalpinia pulcherrima)

Fig.4.23: Allamanda (Allamanda cathartica)

Fig. 4.24: Bougainvillea (Bougainvillea sp.)

Fig. 4.25: Gurhal (Hibiscus rosasinensis)

Fig. 4.26: Raktak (Ixora sp.)

Fig. 4.27: Oleander (Nerium oleander)

Fig. 4.28: Red powder puff (Calliandra sp.)

Fig. 4.29: Night queen (Cestrum nocturnum)

Fig. 4.30: Scarlet bush (Hamelia patens)

Fig. 4.31: Kamini (Murraya exotica)

Fig.4.32: Mussaenda (Mussaenda sp.)

Fig. 4.33: Chandani (Tabernaemontana divaricata)

Fig. 4.34: Tecoma (Tecoma gaudichaudi)

Medicinal shrubs

These shrubs, apart from their ornamental value, are also grown for their medicinal properties. Different parts of these plants are used in formulating various medicines and healthcare products. Some of such shrubs are *Adulsa*, *Catharanthus,* Chitrak, Davana, Lavender, *Ocimum,* Sarpagandha, etc.

Holy shrubs

These shrubs are worshipped or their flowers are used for offering to gods and goddesses during religious functions. Such shrubs are *Barleria, Crossandra, Hibiscus rosa-sinensis, Jasminum*, *Nerium, Ocimum*, *Rosa*, *Thevetia*, etc.

Growing of ornamental shrubs

A perennial shrub is a woody plant growing up to a height of 5 m, having many branches arising from the base of the plant. Ornamental shrubs have more variation in their height, texture, and colours of their foliage and flowers.

Uses of shrubs

- They are used for shrubbery borders, ground covers, and specimen plants.
- They can be used for developing hedges around the garden.
- They can be planted in rows as windbreaks.
- They can be grown in pots and arranged in rows as borders.
- They can be trained into topiary to resemble some animals and birds.
- They can be grown for flower production.

Growing Practices for Trees and Shrubs

Soil and climate

For the cultivation of trees and shrubs, soil should be fairly deep, rich in organic matter, and well-drained. However, trees and shrubs can be grown at almost all the places. There are tropical, sub-tropical, and temperate plants. Tropical ones require higher

temperature conditions. Temperate plants are grown in cooler climates. As they are perennial and permanent in habit, seasonal variations have little effect on them.

Manure and fertiliser application

These are trees and shrubs suiting to all the locations and soils. Highly alkaline, salt affected, acidic, and waterlogged soils should be avoided but there are a few species being grown even in such conditions.

Pits of the dimension of one cubic metre should be dug before the planting of trees and of 45 × 45 × 45 cm for shrubs. The soil taken from the pits should be mixed with 25 kg of well rotten farmyard manure in case of trees and 3–5 kg in case of shrubs before refilling. The pit can be drenched with chlorpyriphos at 2 ml/litre before planting to protect against ants and termites. The pits can be exposed to sunshine for atleast a month before planting. The saplings are planted without disturbing the original earthball. If they are in polythene bags, they should be cut open without disturbing the roots. The trees and shrubs are planted and the soil refilled, firmed up, and saturated with water.

Criteria for selection of shrubs and trees

Shrubs and trees for a particular locality, are selected depending on several factors like availability of space, sunlight, humidity, temperature, spread, and height of the shrub or trees, type (for example, flowering or foliage), colour of flower, fragrance, etc. Taller plants require more planting space. *Mussaenda philippica* cannot tolerate extremes of weather and there are many other such shrubs and trees. People like planting shrubs having fragrant flowers, especially the ones such as *Cestrum nocturnum* or various *Jasminum* species near bedrooms, and there are other shrubs which require humid climate for their luxurious growth such as *Gardenia*, *Ixora singaporensis*, etc.

Propagation

Trees and shrubs are propagated through seeds, cuttings, and layering. Most trees and a few shrubs are

multiplied only through seeds such as *Calliandra* sp., *Stenolobium stans, Caesalpinia pulcherrima, Thevetia peruviana,* etc. A large number of shrubs, such as *Hibiscus rosa-sinensis, Achania malvaviscus, Jasminum sambac, Bougainvillea*, *Cestrum diurnum, Cestrum nocturnum*, etc., and a few trees are also propagated by cuttings. Generally, only those are propagated through cuttings where seed-propagation is a problem, and where cutting propagation is a problem, these are propagated even through layering. *Magnolia, Ixora* sp., some species of *Jasminum*, *Mussaenda*, etc., are propagated by layering. The best season for propagation by cuttings is the rainy season.

Season of planting

The time of planting depends on the location and tree type. In general, planting can be done with success during the rainy season. In heavy rainfall areas, planting may be done at the fag end of the rainy season. In mild climate, as of Bengaluru, planting is possible round the year, except during March–May. In the hills, planting is done either in spring or in the summer season.

Maintenance

Immediately after planting, the pits or furrows are watered, and these are watered frequently for a few weeks till they are well established. Frequency may depend upon the plant type, soil texture, and weather condition. Weeds should be removed regularly, otherwise they compete with the main plant for nutrients and moisture. These being woody plants require continuous and careful pruning. Well-grown trees generally do not require pruning but shrubs require it, and it is done just after when flowering is over. These are pruned immediately after flowering where blooming occurs on old canes, but in case where blooming occurs on new canes, pruning is done 45–60 days earlier. Shrubs which are winter flowering in nature such as *Poinsettia pulcherrima* are pruned at the end of the summer season, whereas others are pruned in the winter season.

Procedure

A. Planting

- Dig a pit measuring one cubic metre for trees and 45 cm × 45 cm × 45 cm for shrubs.
- Mix FYM with the top soil.
- Planting should be done in the middle of the pit, with the help of a planting board when the formal planting in line is to be done.
- Provide staking for better establishment.
- Press the soil around the plants by trampling over with your feet while planting.
- Bury the stem underground as much as it was in the nursery.
- Water liberally after planting.

B. Planting of shrubbery

- Make an informal bed. The size will depend as per available space.
- The outline of the bed is to be marked by a thick wet rope.
- Dig the bed to a depth of 45 cm.
- Mix FYM (4–6 kg per square metre) into the soil.
- The shrubs are planted according to their height—the dwarf ones should be in the front, followed by medium ones, and taller ones in the back.
- For a double-faced shrubbery, the same sequence is followed on both the sides by putting the tallest ones in the middle.
- Both foliage and flowering types are planted together.
- Cover the vacant spaces with sub-shrubs, bulbs, or herbaceous plants, such as *Haemanthus*, *Hemerocallis*, *Pilea*, *Zebrina pendula*, *Zephyranthus*, etc.

Topiary

This is an art of cutting or training trees and shrubs or sometimes even certain climbers into specified shapes, initially a feature of Italian gardens, which was quite rampant during the sixteenth and seventeenth centuries, though it originated at the end of the first century BC. It spread throughout Europe from Italy. While making

NOTES

topiary, various formal and informal simple or complex shapes are given such as birds, animals, etc. The plants most suitable for topiary are *Clerodendron inerme*, *Casuarina equisetifolia*, *Duranta plumieri*, *Euonymus, Ficus benjamina*, *F. panda, Dodonaea, Juniperus, Ligustrum, Myrtus, Osmanthus, Phillyrea, Rosmarinus, Vernonia elaeagnifolia*, etc.

Climbers

A climber is a weak-stemmed herb or shrub requiring some post for growing up, mostly having special structures to climb over the supports. They are useful as specimen plants, for making topiary, for screening to create privacy, to cover an area, to screen or conceal the walls or unattractive objects, as a fence, as a background for perennial border especially for small places where they take much less room than shrubs, for covering arches and pergolas, and overall for their green effects and beautiful flowers of attractive colours, shapes, and sizes. These are commonly trained on walls, trees, arches, trellises, and pergolas.

They have weak stems, and therefore are unable to grow straight on their own. These require support to reach an open atmosphere with ample sunlight. Some have modified organs such as tendrils, thorns, roots (haustorium), and rootlets, etc., to climb over a support. Twiners (creepers) differ from climbers in the way that they do not possess such modified organs but twine around the support, cover it, and reach the top. As per the growth habit, these are divided as follows:

(i) *Twiners*

These are climbing plants which twine themselves spirally around another plant or some other object such as *Rosa banksiae alba*, *R. b. lutea*, *Wistaria*, etc.

(ii) *Climbers*

Their special organs are modified leaf-stalk (tendril), hook-like thorns, etc., which provide support to the plants for climbing. Examples of such plants are Epipremnum, Monstera, Philodendron, Raphidophora, Scindapsus, etc.

(iii) *Ramblers*

The plants which do not succeed in their efforts to climb but manage to spread around by supporting themselves on stones or branches. Such plants are *Quisqualisindica, Rosa wichuriana,* etc.

(iv) *Creepers*

The climbers of this group are too weak to rise vertically upwards. They have roots (haustorim) at their nodes for this purpose, such as *Ficus pumila, Parthenocissus,* etc.

(v) *Trailers*

These are similar to creepers, but do not have roots at the nodes.

Categories of climbers as per their use

Climbers vary in their growth habits, some being known for their foliage and some for the flowers, while certain others for both.

Horticulturally, climbers can be classified into different groups based on the growth, flowering and purpose for which they are used:

(i) *Showy flowering climbers*

They flower at a certain time of the year with attractive flowers such as *Adenocalymma aliceum, Allamanda cathartica, Antigonon leptopus, Ipomoea horsefaliae, Passiflora coerulea, Petrea volubilis, Quisqualis indica, Rosa banksiae lutea, Thunbergia grandiflora, T. mysorensis, Wistaria chinensis, Flaming trumpet,* etc.

Fig. 4.35: Flaming trumpet (Pyrostegia venusta)

(ii) *Climbers for foliage*

These are the climbers which are grown only for their beautiful foliage; however, flowers may or may not be of significant value. These climbers are trained to climb over walls or on the strong trunk of the trees. Such climbers are *Ficus repens, Philodendron, Pyrostegia ignea, Scindapsus, Vernonia elaegnaefolia, Indian Ivy,* etc.

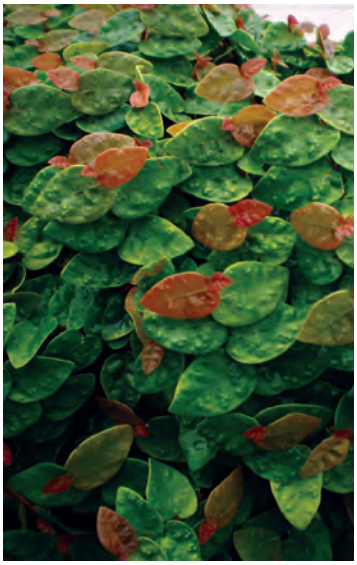


Fig. 4.36: Indian Ivy (Ficus repens)

(iii) *Climbers with scented flowers or foetid foliage*

Under this, the climbers which bear scented flowers are included, such as *Adenocalymma aliceum, Jasminum auriculatum, J. grandiflorum, J. officinale, J.sambac, Rosa banksiae alba, R. moschata,* etc.

(iv) *Climbers for partial shade*

These are the climbers which are grown under filtered sunshine such as *Clerodendron splendens, Petrea volubillis,* etc.

(v) *Heavy climbers*

These climbers have more luxuriant vegetative growth and cover a large area, such as *Antigonon leptopus, Bignonia magnifica Bougainvillea* spp., *Quisqualis indica, Wistaria sinensis,* etc.

Fig.4.37: Coral vine (Antigonon leptopus)

Fig. 4.38: Rangoon creeper (Quisqualis indica)

(vi) *Climbers for hedge making*

These climbers are strong growing and most suitable for hedge making so they are highly amenable to frequent trimming and prunings. Such climbers are *Bougainvillea* spp., *Clerodendron inerme,* etc.

(vii) *Climbers for indoor decoration*

These climbers being shade-loving, are more suitable for pot culture indoors, and such plants are *Asparagus plumosus, Monstera deliciosa, Philodendron* spp., etc.

Growing practices

Soil

Climbers need well-drained soils, preferably a loam. Generally a pit size of 50 × 50 × 50 cm is dug out and the dug out soil is mixed with 5 kg of well rotten FYM. The sapling of the climber is removed from the polythene bag and planted by firming up the soil, immediately followed by irrigation. The climber can be trained on a wall, arch, pergola, or any other support. An annual application of FYM is required.

Propagation

Climbers are commonly propagated by seeds, cuttings, and layering.

List of common shrubs

Flowering shrubs

S. No.	Botanical names	Common names
1	*Allamanda cathartica*	Allamanda
2	*Bougainvillaea spp.*	Bougainvillaea
3	*Caesalpinia spp.*	Peacock flower
4	*Calliandra spp.*	Calliandra
5	*Cestrum nocturnum*	Night queen
6	*Clerodendron spp.*	Clerodendron
7	*Duranta spp.*	Duranta
8	*Hamelia patens*	Scarlet bush
9	*Hibiscus spp.*	Hibiscus
10	*Ixora spp.*	Ixora
11	*Jasminum spp.*	Jasmine
12	*Lagerstroemia indica*	Lagerstroemia
13	*Lantana camara*	Wild sage
14	*Lawsonia inermis*	Mehndi
15	*Murraya exotica*	China box
16	*Mussaenda spp.*	Mussaenda
17	*Nerium oleander*	Oleander
18	*Nyctanthus arbortristis*	Parijatha
19	*Tabernaemontana divaricata*	Wax flower, Chandni
20	*Tecoma gaudi-chaudi*	Trumpet flower

Foliage shrubs

S. No.	Botanical names	Common names
1	*Acalypha* spp.	Acalypha, Chenille plant
2	*Aralia* spp.	Aralia
3	*Codiaeum* spp.	Croton
4	*Eranthemum* spp.	Eranthemum
5	*Phyllanthus*	Phyllanthus
6	*Sanchezia nobilis*	Sanchezia
7	*Clerodendron inerme*	Clerodendron
8	*Duranta plumieri*	Duranta

Fig. 4.39: Croton (Codiaeum variegatum)

List of common climbers

S.No.	Scientific names	Common names
1	*Allamanda cathartica*	Malatilata
2	*Antigonon leptopus*	Coral creeper
3	*Adenocalymna aliceum*	Garlic creeper
4	*Pyrostegia ignea*	Golden shower
5	*Beaumontia grandiflora*	Nepal trumpet climber
6	*Clitoria ternatea*	Clitoria
7	*Clerodendron splendens*	Clerodendron
8	*Ficus repens*	Ficus
9	*Ipomea learii*	Blue morning
10	*Ipomea palmata*	Railway creeper
11	*Jasminium grandiflorum*	Jasmine
12	*Monstera deliciosa*	Monstera
13	*Petrea volubilis*	Purple wreath
14	*Quisqualis indica*	Rangoon creeper
15	*Thunberiga grandiflora*	Thunberiga
16	*Vernonia elaegnifolia*	Curtain creeper

Practical Exercise

Activity 1

Demonstrate the planting of a shrub.

Material Required

Spade, *khurpi*, pots, measuring tape, lime powder, planting board, stake, FYM, insecticide, and shrubs.

Procedure

- With the help of a measuring tape, measure the area of 45 × 45 × 45cm.
- For digging a pit, mark this area with lime powder.
- Dig a pit with the help of a spade.
- Mix FYM with the top soil excavated from the pit.
- Place some fumigant (insecticide) at the base of pit.
- Put a layer of soil excavated from the pit over the fumigant.
- Plant the shrub in the middle of the pit, with the help of a planting board when the formal planting in line is to be done.
- Provide staking for better establishment.
- Fill the pit with FYM and soil mixture.
- Press the soil around the shrub by trampling over with feet.
- Water liberally after planting.

Check Your Progress

A. Fill in the Blanks

1. The group of plants which remains productive for many years is _____.
2. The plants which have soft and succulent stem are _____.
3. Climbers are perennials which have _____ and need support to climb.
4. Medium size bushy plants are known as _____.
5. The plant with well defined single woody stem and branching at crocks is known as a _____.
6. The height of a tree may be more than _____ meters.
7. Continuous growth is shown by _____.

B. Multiple Choice Questions

1. In _____, the growth phase is discontinuous.
   (a) Decidious trees
   (b) Evergreen trees
   (c) Annuals
   (d) None of the above
2. In India, shrubs are mostly planted during the _____ season.
   (a) Rainy
   (b) Winter
   (c) Summer
   (d) None of the above
3. _____ is an art of giving shape of an object to the plants.
   (a) Girdling
   (b) Pruning
   (c) Topiary
   (d) Goottee
4. _____ is not a type of climber.
   (a) Twiners
   (b) Ramblers
   (c) Rubber plant
   (d) Trailers
5. Money plant is an example of a _____.
   (a) Tree
   (b) Shrub
   (c) Climber
   (d) Rambler

NOTES

C. Subjective Questions

1. What are perennials? Give the important characteristics of perennials.

2. What are the different types of perennials?

3. Give the important uses of perennials.

4. Write down the importance of trees.

5. Write down the uses of shrubs.

6. Describe the propagation of shrubs.

7. How can trees be planted?

8. What is topiary work? Name the plants suitable for topiary.

9. What are trees? How are they classified?

10. What are shrubs? How are they classified?

_____

_____

_____

11. What are the different types of climbers? Explain with suitable examples.

_____

_____

_____

12. Distinguish between:
    - climbers and creepers
    - trees and shrubs
13. Give five examples of each of the plants suitable for —
    - Flowering trees
    - Flowering shrubs
    - Flowering climbers
    - Ornamental shrubs
    - Bonsai
    - Indoor plants
    - Palms
    - Ornamental trees

D. Match the Columns

A	B
1. Evergreen tree	(a) *Saptparni*
2. Foliage climber	(b) *Ashok*
3. Medicinal shrub	(c) *Ocimum*
4. Shady tree	(d) *Dalbergia sissoo*
5. Erect growing	(e) *Vernonia elaeagniefolia*

Session 2: Indoor Plants

Indoor (house) plant

A plant which is ornamental for its foliage, flowers or both, and satisfactorily adjusts to the indoor environmental conditions (temperature, humidity, light, and aeration) of a house is known as an indoor plant. These give a sensation of enchantment in patios, porticos, living rooms, bedrooms, bathrooms, stairs, window sills, walls, roof hangings, and rooftops. These are grown primarily for beautification and secondly, for keeping the indoor environment free of pollution. There is a

range of evergreen foliage plants, such as *Aglaonema, Aloe, Asparagus, Aspidistra, Beaucarnea, Calathea, Chlorophytum, Dieffenbachia, Haworthia, Maranta, Monstera, Peperomia, Pilea, Ruscus, Sansevieria, Scindapsus,* etc., and a range of flowering indoor plants such as *Aeschynanthus, Chrysanthemum, Cyclamen, Haemanthus, Hippeastrum, Huernia, Stapelia*, *Zantedeschia,* etc. Many of the slow-growing bamboos, palms and trees adorn the indoors for many years until these attain a particular height. Orchids, bromeliads, herbs, various bulbous plants, cacti, and other succulents are most suitable for indoor growing. However, there should be two to three such sets, out of which, the plants kept indoors should be replaced every week with the set kept outside in the filtered light as every plant whether it is kept indoors or outdoors, requires light for manufacturing its food. Some major benefits of keeping these plants are as follows:

- Such plants beautify the surroundings.
- They remove indoor air pollution, and in turn supply fresh oxygen.
- They absorb dust, various types of odours, and aerosols.

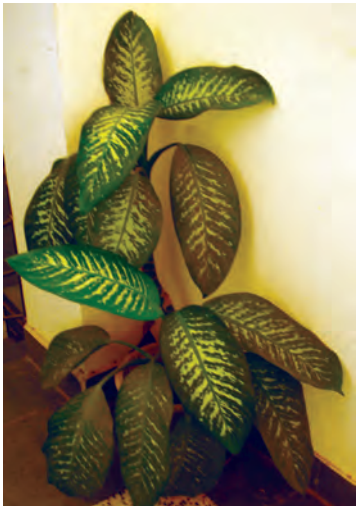


Fig. 4.40: Dumb canes (Dieffenbachia)

Types of indoor plants

Foliage plants

The plants possessing graceful green-coloured or variegated leaves of various shapes are *Aglaonema, Alocasia*, *Anthurium*, *Araucaria*, *Asparagus*, *Begonia rex*, *Brassia actinophylla*, *Caladium, Calathea*, *Chlorophytum*, *Coleus*, *Dieffenbachia*, *Maranta, Pepromia*, *Philodendron*, *Pilea*, *Sansevieria*, *Scindapsus*, *Tradescantia*, *Zebrina pendula,* etc.

Fig. 4.41: Maranta (Maranta arundinacea)

Fig. 4.42: Small-leaf spiderwort (Tradescantia fluminensis)

Fig. 4.43: Money Plant (Scindapsus sp.)

Palms

These (Palmae) are a group of plants mostly with single stem and large leaves, suitable for growing in large halls or rooms. The leaves of these plants present a wonderful variety in form and structure. Some of the useful palms are *Howea belmoreana* (dwarf palm), *Livistona chinensis* (Chinese fan palm), *Neanthe bella* (dwarf palm), *Phoenix roebelenii* (pygmy date palm), Aneca palm etc.

Fig. 4.44: Areca palm (Dypsis lutescens)

Bromeliads

They are interesting epiphytic plants, mostly succulents, with attractively coloured leaves and flowers. Those grown indoors are *Billbergia nutans, Cryptanthus, Till and sia, Pitcairnia balansae,* etc.

Indoor flowering plants

These indoor plants produce beautiful flowers and such plants are *Anthurium, Begonia* (tuberous and fibrous rooted), *Beloperone, Hoya carnosa, Saintpaulia* (African violets), *Rhododendron simsii* (azalea), etc.

Classification of indoor plants

Indoor plants can also be classified into three groups based on the light requirement as high, medium and low. Without sufficient light, carbohydrate manufacturing is minimised but the plants with dark green leaves can survive on a very little light, though certain others require plenty of light. Variegated plants need plenty of filtered sunlight. *Aphelandra, Aspidistra,* and *Ruscus* may not die in low light zone, but may lose their variegation. If there is insufficient light, the plant will produce more chlorophyll at the expense of variegation.

High light requiring plants

Those plants, which require high light conditions, can be placed in the verandah, window edges or one metre away from window. Some of such plants are *Acalypha*, African violet, *Alocacia*, *Aloe vera*, *Anthurium*, *Aphelandra*, *Asparagus*, *Aucuba*, Bamboo, *Begonia*, bleeding heart vine (*Clerodendrum), Buxus*, Cactus, *Caladium*, *Codiaeum, Coffea, Pilea* (creeping Charlie), *Cyclamen*, Devil's ivy, *Dieffenhachia* (dumb cane),

Ferns, *Hibiscus*, *Hoya*, Jade plant, *Kalanchoe*, Palms, *Peperomia*, *Poinsettia*, *Dracaena*, and so on.

Medium light requiring plants

These plants can be placed 1.5 to 3 m away from windows. Some of the plants suitable for such conditions are *Aglaonema*, *Pilea*, *Anthurium*, *Aphelandra*, *Aspidistra, Asplenium, Begonia*, bromeliads, *Calathea*, *Dracaena*, Ferns, *Spathiphyllum* (Madonnalily), *Monstera*, *Pepromia*, *Philodendron*, Rubber tree, *Syngonium*, etc.

Low light requiring plants

These plants can be placed 4 m away from the windows in a bright room, in corners, behind doors, and in very small rooms, and the plants suitable for this condition are *Aglaonema, Aspidistra, Bromeliads* with green leaves, *Calathea, Spathiphyllum, Maranta*, *Philodendron, Ruscus, Syngonium* (geen leaved ones), etc.

Growing Practices

Preparation of potting mixture

Potting mixture comprises of two parts loamy soil, one part leaf mould, $^{1}/_{2}$ part well-rotten manure, and ½ part sand. For ferns and bulbous plants, the mixture should be porous comprising of coarse sand, light garden soil, and leaf mould. Neem cake and bone meal may also be used in small quantities as nutrients.

Potting

For planting the house plants, the pot is filled with the potting mixture leaving 2.5 cm from the brim. Before the filling of pots, pebbles or crocks at holes should be placed to avoid clogging of the drainage hole.

Repotting

For the better growth of indoor plants, repotting or transplanting of the established plants is done once in a year. Repotting is transferring of plants from pots, and planting them in the same or a different pot. During repotting, old potting mixture is replaced by new potting mixture and overgrown roots are removed.

Planting

Planting of deciduous indoor plants is done in February–March, whereas evergreen plants are planted in July–August. Staking (like moss column structures) is also provided depending upon the plant type.

Care and maintenance

House plants require proper care and management throughout the year. Care has to be taken regarding proper:

- watering
- manuring
- disease and insects-pest control
- proper exposure to light

Keeping plants at the same place for a long period of time may result in reduced growth with the yellowing of leaves. Therefore, these require to be placed at regular intervals (7–15 days) by changing their location and sides where these can get ample light during winter and may also have sufficient protection from fierce sunshine in hot summer, *vis-à-vis* ample aeration.

Frequent watering should be carried out during April–June when the plants are in active growth, in comparison to the cold season. Over-watering may lead to the yellowing of leaves and fungal diseases but less watering may restrict plant growth. Therefore, the frequency of irrigation is to be decided depending upon the weather conditions and the type of plant species.

House Plants

Foliage type

Plants having ornamental foliage, though inconspicuous flowers.

S. No.	Botanical names	Family
1.	*Aglonema commutatum*	Araceae
2.	*Calathea lietzei*	Marantaceae
3.	*Dracaena fragrans*	Agavaceae
4.	*Excoecaria bicolor*	Euphorbiaceae
5.	*Maranta arundinacea 'Variegata'*	Marantaceae
6.	*Pandanus baptistii*	Pandanaceae
7.	*Schefflera arboricola*	Araliaceae

8.	*Tradescantia albiflora 'Albo-vittata'*	Commelinaceae
9.	Pothos	Araceae
10.	Croton	Euphorbiaceae
11.	*Acalypha*	Euphorbiaceae
12.	*Diffenbachia*	Araceae

Fig. 4.45: Acalypha (Acalypha hispida)

Fig. 4.46: Aglaonema commutatum

Fig. 4.47: Dracaena (Dracaena fragrans)

Flowering Type

Plants that produce conspicuous and attractive flowers are flowering type house plants.

S. No.	Botanical names	Family
1.	*Acalypha hispida*	Euphorbiaceae
2.	*Begonia semperflorens*	Begoniaceae
3.	*Heliconia humilis*	Heliconiaceae
4.	*Kaempferia pulchra*	Zingiberaceae
5.	*Pachystachys lutea*	Acanthaceae

Ferns

Ferns are valued for their beautiful foliage.

S. No.	Botanical names	Family
1.	*Adiantum capillus*	Adiantaceae
2.	*Blechnum gibbum*	Blechnaceae
3.	*Lygodium giganteum*	Lygodiaceae
4.	*Nephrolepis biserrata*	Oleandraceae (Davalliaceae)
5.	*Platycerium bifurcatum*	Polypodiaceae
6.	*Asplenium nidus*	Aspleniaceae

Fig. 4.48: Bird's-nest fern (Asplenium nidus)

Palms

These have elegant foliage in different forms and patterns, such as *Arenga pinnata, Caryota mitis, Licuala grandis, Phoenix canariensis, Rhapis excelsa, Washingtonia filifera*, etc.

Bromeliads

These have colourful leaves in rosette form as well as attractive inflorescence, such as *Aechmea chantinii, Billbergia nutans, Cryptanthus bivittatus* 'Pink Starlite', *Neoregelia carolina* 'Tricolor', etc.

Bulbous plants

These plants include true bulbs but also the plants that grow from tubers, corms, and rhizomes. These are basically the storage organs.

S. No.	Name	Family
1.	Caladium 'Bleeding Heart'	Araceae
2.	Haemanthus multiflorus	Amaryllidaceae

Succulents

These plants are able to store a lot of water in their tissues either in leaves, stems or rootstocks.

S. No.	Names	Family
1.	*Agave americana parviflora*	Agavaceae
2.	*Beaucarnea recurvata*	Agavaceae
3.	*Dudleya virens*	Crassulaceae
4.	*Furcraea gigantia* 'Medio-picta'	Agavaceae

5.	*Kalanchoe blossfeldiana*	Crassulaceae
6.	*Pedilanthus tithymaloides*	Euphorbiaceae
7.	*Sedum morganianum*	Crassulaceae
8.	*Tradescantia sillamontana*	Commelinaceae
9.	*Yucca filamentosa*	Agavaceae

Juvenile trees

There are certain trees which have attractive leaves in the juvenile phase and can also be used as house plants.

S. No.	Name	Family
1.	*Araucaria cunninghamii*	Araucariaceae
2.	*Cycas circinalis*	Cycandaceae
3.	*Ficus benjamina nuda*	Moraceae
4.	*Juniperus chinensis*	Cupressaceae
5.	*Thuja orientalis*	Cupressaceae

Bonsai

The word bonsai (pronounced as bonsigh) is a combination of two Japanese words *bon* meaning 'shallow pan or tray' and *sai* meaning 'planting', that is tray planting. Originally it is a Chinese art, in China it is called *penzai* or *penzing* which also means 'tray plant' or 'tray scenery'. In Japan, they focus more on the individual tree in pots, while in China, they focus this art towards landscaping. Plants can be grown in shallow containers with restricted growth. In short, the plants (trees, shrubs, and climbers) are maintained in miniature form either singly or in combination with rocks of many forms to show the dignified beauty of an aged tree which has survived the good and bad times of nature for centuries as expressed in the form of trees found in nature. its originating the trunk, the bark and branches. The plants most suitable for bonsai are *Acer palmatum,* Bamboos, *Butea*, *Callistemon, Ficus* spp., *Ginkgo, Juniperus, Lespedeza, Pinus*, *Prunus, Ulmus, Wistaria, Zelkova,* etc.

Classification of bonsai according to the height of the main trunk

Large ones

These include four handed and six handed bonsai measuring above 60 cm to 152 cm in height, and also up to 203 cm with eight handed bonsai (Imperial bonsai).

Medium ones

These are quite popular, and include two handed bonsai and remain within the limit of 30–60 cm.

Small bonsai

It includes either two or one handed bonsai and its height is restricted below 30 cm.

Miniature bonsai

Its height restricts it to 15–20 cm and these are of four types. These types are very difficult to maintain in their true forms, especially the small ones.

Bonsai tools

Shears and scissors, concave pruners, wire cutters and pliers, root hook, knob cutter, brushes, anodised aluminium and annealed copper wires, turn table, watering can, and trays.

Plants suitable for bonsai making

Acacia arabica (black babul), *Achras sapota* (sapota), *Adansonia digitata* (baobab), *Adenium obesum* (desert rose), *Albizia julibrissin* (silk tree), *Araucaria cookii* (new caledonia pine), *Bucida spinosa* (spiny black olive), *Bougainvillea* sp. (bougainvillea), *Buxus harlandi* (Chinese boxwood), *Caesalpinia coriaria* (divi divi), *Salix babylonica* (weeping willow), *Callistemon citrinus* (bottlebrush), *Carmona retusa* (scorpion bush), *Chamaecyparis obtusa* (cypress), *Commiphora mukul* (guggul), *Crassula arborensis* (silver jade plant), *Duranta repens* (golden dewdrop), *Morus alba* (mulberry), *Murraya paniculata* (manokamini), *Elaegnus angustifolia* (thorny silver berry), *Fagus sylvatica* (common beech), *Ficus benjamina* (weeping fig), *Ficus carica* (common fig),

NOTES

Ficus religiosa (pipal), *Ficus retusa* (chilkan), *Gardenia jasminoides* (Cape jasmine), *Hibiscus rosasinensis* (hibiscus), *Inga dulcis* (Madras thorn), *Jacaranda mimosifolia* (blue jacaranda), *Juniperus communis* (common juniper), *Lagerstroemia* sp. (jarul), *Magnolia* sp. (magnolia), *Portulacaria afra* (jade plant), *Punica granatum* (pomegranate), *Putranjiva roxburghii* (child life tree), *Schefflera arboricola* (umbrella plant), *Serissa foetida* (serissa), *Tamarindus indica* (tamarind), *Ulmus parviflora* (chinese elm), *Vitex negundo* (vitex), *Wrightia religiosa* (wrightia), etc.

Making of bonsai

For bonsai making, selection of plant is most important, and then comes the procedure through root pruning, branch cutting, twisting, wiring, and tying to a direction to make these informal or slanting. Generally, non-rusting copper wiring is used. After the objectives are attained, the wires are revoved gently for reuse. These are planted in appropriate and suitable containers or pots filled with the right quantity of soil mixture. Fertiliser is given barely so that these may not attain the luxurious growth but also such that these do not die and so is the case for watering. Any extra growth should be removed immediately.

Practical Exercise

Activity 1

Identify indoor plants.

Material Required

Potted lants or its branches such as Croton, Acalypha, Diffenbachia, Nephrolepis biserrata, Araucaria cunninghamii, Cycas circinalis, Thuja orientalis, etc.

Procedure

- Identify the plants and write their names and importance.

Check Your Progress

A. Fill in the Blanks

1. A _____ is a plant that is grown indoors in places such as residences and offices.

2. The group of plants with a single stem and large terminal leaves are _____.
3. Planting of evergreen indoor plants is done in_____.
4. Japanese words *bon* means _____ or tray and *sai* means _____.
5. In China, bonsai is called _____.

B. Multiple Choice Questions

1. Fingertip bonsai size restricts to _____ .
   (a) 5–7 cm
   (b) 5–10 cm
   (c) 7–9 cm
   (d) 5–12 cm
2. Bromeliads are interesting epiphytic plants and mostly _____ .
   (a) succulents
   (b) hardy
   (c) woody
   (d) None of these
3. Which one of these is not a palm?
   (a) Phoenix roebelenii
   (b) Livistona chinensis
   (c) Howea belmoreana
   (d) Bilbergia nutans
4. Which one of these is not an example of fern?
   (a) Adiantum capillus
   (b) lechnum gibbum
   (c) Nephrolepis biserrata
   (d) Begonia semperflorens

C. Subjective Questions

1. What do you mean by indoor plants? Give their different types.

   _____

   _____

   _____

2. What are palms?

   _____

   _____

   _____

3. What are bromeliads?

   _____

   _____

   _____

NOTES

4. Write down the procedure of making bonsai.

_____

_____

_____

D. Match the Columns

A	B
1. Large bonsai	(a) Above 60 cm
2. Ferns	(b) Bamboo
3. Succulents	(c) Adiantum capillus
4. Suitable for bonsai	(d) Agave Americana parviflora

Unit 5

Post Harvest Management and Value Addition

Floriculture industry in India comprises of both cut and loose flowers, the former for export purpose, is being produced mostly under protected conditions. Flowers are highly perishable commodity in nature and owing to poor keeping quality, the post harvest losses in floriculture sector is more than any other agriculture sector. Although, there has been significant increase in the area, production and productivity of flower crops in the last two decades, there is an urgent need to reduce or check the huge post harvest losses of floriculture produce in terms of the value of the products.

The post harvest behaviour of flowers is an outcome of different physiological activities occurring in leaves, stem, flower bud, peduncle, or scape, connecting bud to the stem. The nature and amount of post harvest losses in cut flower industry is different for each crop and/or cultivar. Therefore, careful handling of flowers after harvesting, is of utmost importance.

Post Harvest

Since flowers are a highly perishable commodity in nature and the post harvest losses of flowers range between 25–40% in India, that is why, their proper management is very important to avoid the losses for

maximum profit. Post harvest management includes the practices that are followed from the harvesting stage till the flowers reach to the consumer.

Stage of Harvesting

The correct stage of harvesting depends on the crop, variety, market distance, and consumer preference. To have a better vase life, these flowers should be harvested at an appropriate stage. In general, the flowers for distant markets are harvested at tight bud stage, and for local markets at a later stage, that is at opening or opened stage. Standard harvesting stage of various flowers is furnished below.

Crop	Right stage of harvest
Rose, carnation	Tight bud stage
Anthurium, gerbera, orchids	Fully open stage

Time of Harvest

Generally, the flowers should be harvested during the cool hours of either the morning or evening to extend the life and to maintain their quality.

Activities involved in Post Harvest Handling

Harvesting at the correct stage

Every specific crop should be harvested at the right stage to extend the vase life of flowers.

Conditioning or hardening

This is achieved by treating the flowers with de-mineralised water supplemented with germicides and acidifiers. It is effective only if its stems are re-cut under water and placed immediately in the conditioning solution. It is normally done by saturating with warm water at room temperature, and then overnight in a cool room.

Pre-cooling

To neutralise the field heat, flowers must be pre-cooled immediately after harvesting to slow down the respiration and transpiration rate so that the manufactured food is preserved, which in turn will cause the extension of

vase life. Flowers can be pre-cooled by placing them in a cold storage without packing or in open boxes until they reach the desired temperature. Pre-cooling temperature varies with the species and cultivars.

Pulsing

This sustains the life of flowers with full vigour until these reach the customers. This is a short-term high concentration treatment given to cut flowers under light before packing. Specific formulations are developed for different flowers. The cut flowers may be pulsed with floral preservatives containing sugars, and antimicrobial cum anti-ethylene substances. The bud or open flowers are treated for 6 to 24 hours in a pulsing solution, of which the main ingredient is sugar. The percentage varies with species and cultivar, as for rose and chrysanthemum, it is 2–6% sucrose + 100 ppm aluminium sulphate + 200 ppm 8-HQC.

Activity

Preparation of a simple pulsing solution for rose

5% sucrose and 300 ppm citric acid

Material Required

Cut flowers, 60 g sugar, 300 mg citric acid, 1 litre distilled water

Procedure

- Citric acid and sugar are to be thoroughly dissolved in distilled water, in a container.
- Cut ends of rose stems must be placed for 12 hours under light in the solution.
- Observe the shelf life of flowers in between the normal water and pulsing solution.

Grading

It is the separation of flowers into different categories according to well-defined international quality standards, which determines their price. Generally, the flowers are graded on the basis of freshness, stem length, and flower diameter. Flowers should be free from bruising injury (damage to the flower due to improper and rough handling), dirt, or foreign material, nutritional,

Fig. 5.1: Grading of Rose flower

chemical, or mechanical abnormality, free from disease and pest or petal discolouration. Size of flowers should be representative of the required cultivar. Bright, clean, and firm flowers must be selected. Flowers with different stem lengths must not be mixed together. Cut stem must be straight and strong enough to hold the flowers in an upright position. Flowers should be cut at the proper stage as per the specification, and must be at a uniform stage of development.

Types of packaging material

For local market, it consists of locally available packaging material, but for distant market, specific corrugated cardboard or fibre board boxes are required for packaging.

Fig. 5.2: Carnation Packaging

Packaging of cut flowers

To ensure that the freshness of flowers reaches the consumer, cut flowers are packed in proper packages to lower the rate of transpiration and respiration. The boxes must be airtight and shock-free so that the quality and shelf life of cut flowers are protected. Generally, the flowers are packed in 'corrugated fibreboard boxes' (CFB) with ventilation, and lined internally preferably with a polythene sheet.

Storage

This can be by done in different ways. Cold storage is the most commonly used method for cut flowers. In cold storage, the flowers can be stored, by keeping the cut

stems in a bucket, containing cold filtered or distilled water (wet storage), or packed in CFB boxes and stored (dry storage). Different flowers can be stored without losing quality under cold storage for different durations as given below.

Crop	Method	Temperature (°C)	Duration of storage
Rose	Wet	0.5 – 2.0	1 week
	Dry	–0.5 – 0.0	2 weeks
Orchid	Dry	13.0	2 weeks
Anthurium	Dry	13.0	3 – 4 weeks
Chrysanthemum	Dry	–05 – 0.0	3 – 4 weeks
Gladiolus	Wet	1.6 – 4.4	6 – 9 days

The storage room should be ethylene-free, and RH of the room should be 90 – 95% with gentle air movement throughout.

Transportation

For long distance shipment of cut flowers, after proper packing, these are usually transported through road (truck), air or water (ship). For short distance taking less than 20 hours, the flowers can be transported in insulated trucks without refrigeration after pre-cooling and proper packaging. Transportation by air is best for distant markets as the expense involved in air-lifting would be compensated.

Cool chain

The flowers should be kept under optimal cool temperatures, preferably throughout their post harvest life (starting from harvesting till it reaches to the consumer), and this is popularly known as cool chain.

Bud opening solution

Buds smaller than optimum size usually do not open to their full size in usual case so these are not considered the best quality flowers until these are treated with full opening solution. This solution should contain optimum amount of sucrose, germicide, ethylene inhibitor, and

some hormones. Treatment given for full commercial opening in case of a bud rose is 2 per cent sucrose + 300 ppm 8-HQC; for chrysanthemum 2% sucrose + 200 ppm 8-HQC + 75g citric acid + 25 ppm aluminium sulphate; and for tuberose 3% sucrose + 0.03% 8-HQC + 0.01% aluminium sulphate.

Vase solution/holding solution

Cut flowers are held in vase solution of sucrose or other such chemicals at low concentration to lengthen the life of the flower.

Crop	Holding solution
Rose	2% sucrose + 100 ppm aluminium sulphate + 200 ppm 8-HQC
Chrysanthemum	2% sucrose + 0.01% aluminium sulphate for 24 hours
Gladiolus	20% sucrose + 200 ppm 8-HQC for 24 hours
Gerbera	10% sucrose + 200 mg/l silver nitrate for 24 hours
Anthurium	BA 50 ppm for 12 hours

Value-added products

Bouquet

These are usually made with the help of cut flowers on the background of fillers (cut greens) in different shapes (cone, oblong or cylindrical). The floral bouquets are encased in polythene films, bamboo baskets, cardboard sheets, etc. Flowers arranged in baskets similar to bouquets can also be used for table arrangement.

Garlands

Loose flowers such as rose, chrysanthemum, jasmine, marigold, tuberose, crossandra, etc., are held together in artistic manner with the help of threads.

Veni

A flower arrangement used to decorate hair mostly in southern and eastern parts of India.

Gulkand

It is a product prepared from rose petals. The petals of Edward rose (*Rosa bourboniana*) are generally used to prepare this product. It is prepared by mixing equal quantity of sugar and petals in alternating layers in a container, and pounded under the sun.

Rose water

It is a by-product while rose flowers are used for the distillation of essential oils. The petals of *Rosa damascena* are used for obtaining rose oil and rose water through steam distillation.

Dry flowers

Dry flowers are prepared by dehydrating fresh flowers either by natural or artificial means. Such flowers are enjoyed during the off-season, especially when either the fresh flowers are not available or are too costly. The most common methods of drying flowers are sun drying, shade drying, press drying, and oven drying. The dried flowers and foliage are used to make greeting cards, paper weight, candles, handmade paper, wall hangings, lampshades, swags, wreaths, boutonnieres, etc. At present, plant materials with distinct shapes are used for this purpose. Any interesting and decorative cone, nut, gourd, seedpod, flowers, sugarcane inflorescence, foliage, fruit, and even small graceful tree branches can be modified into dried forms. There are two general categories of dried materials, those collected in an already dry condition and those picked fresh and dried artificially. Most commonly used plant species as dry flowers are *Acroclinium*, *Helichrysum,* larkspur, *Nigella*, rose, statice, stock, etc.

Flower arrangement

This is an aesthetic and artistic form of flower display, which refreshes one's mind and provides livelihood to others. Cut flowers are used for making various flower arrangements on various occasions such as birthdays, wedding parties, and others. These add beauty to the table when used as centrepieces.

Practical Exercise

Activity 1

Visit a flower market or flower shop.

Procedure

Visit a flower market or a flower shop and note down the following information.

- Types of flower
- Packaging material used
- Method of storage of loose and cut flowers
- Types of value added products prepared
- Transportation mechanism of flowers
- Any other relevant information

Check Your Progress

A. Fill in the Blanks

1. Flowers are highly _____ in nature.
2. Post harvest losses of flowers range between _____ in India.
3. Flowers are harvested during the _____ hours of the day.
4. Hardening is achieved by treating the flowers with _____.
5. Pre-cooling slows down the _____ rate.
6. A short-term high concentration treatment given to cut flowers under light is _____.
7. The main ingredient of pulsing solution is _____.
8. Categorising of flowers according to well-defined international quality standard which determines the price is _____.
9. Loose flowers are held together in an artistic manner with the help of threads, this is called _____.
10. A product prepared from the rose petals is _____.

B. Multiple Choice Questions

1. Proper harvesting stage of loose rose is—
   (a) tight bud (b) slightly loose
   (c) half open (d) Fully open
2. Proper harvesting stage of marigold is—
   (a) slightly loose (b) fully open
   (c) Half open (d) Tight bud

3. Which of the following is less sensitive to chilling injury?
   (a) Rose (b) Jasmine
   (c) Gaillardia (d) Marigold
4. Conditioning solution consists of _____ pH.
   (a) 1.5 to 3.0 (b) 3.5 to 4.5
   (c) 5.5 to 6.5 (d) 6.5 to 7.5
5. In which solution, flowers are held for a long duration?
   (a) Conditioning (b) Bud opening
   (c) Pulsing (d) Vase solution
6. Full form of ppm is—
   (a) parts per milligram (b) parts per milliliter
   (c) parts per million (d) pulse per million

C. Subjective Questions

1. Write about the post harvest management of flowers.

   _____

   _____

   _____

2. What is pre-cooling of flowers?

   _____

   _____

   _____

3. How is pulsing solution prepared?

   _____

   _____

   _____

4. What is grading?

   _____

   _____

   _____

5. Write about the bud opening solution of flowers.

   _____

   _____

   _____

6. Write about flower arrangement.

   _____

   _____

   _____

7. Describe the value added products of flowers.

   _____

   _____

   _____

NOTES

D. Match the Columns

A	B
1. Packing of cut flowers	(a) Decorate hair
2. Cool chain	(b) 6–9 days storage
3. Gladiolus	(c) Flowers kept under optimal temperature
4. Veni	(d) CFB

Unit 6

Maintain Health and Safety at the Workplace

Different workplaces have different levels of challenges especially in terms of physical hazards inherent in the nature of work or the workplace. Workplace accidents put a heavy, harmful, unfortunate, and counterproductive impact on workers, their co-workers, and their families. They suffer pain, disability, stress, and in some cases even loss of employment. Hazard is defined as a dangerous condition or event that portends or has the potential to cause injury, threaten life, damage the property, etc. Hazards in agriculture include mechanical hazards, ergonomic hazards, chemical hazards, accidents, hazards related to the occupancy of confined places, occupational diseases, and various other hazards arising from associated land, water, and air. All efforts are necessary for personal safety of the workers and the users of agrochemicals and farm machinery, at all times, on ethical, health, and professional grounds.

Accidents may occur while being at work in the field, transporting animals, and crops, or by falling, slipping, tripping, drowning, machinery hits or by adopting bad or unhealthy work practices. Hazards caused by human

factors, such as those caused by awkward postures, and damage to muscles and tendons, mainly due to poorly designed tools, are of common occurrence at agricultural farms. Hazards related to confined spaces (warehouses, wells, manholes) are of great concern to the safety of workmen.

This unit will help you learn about various health and physical hazards faced by farm workers and the safe work procedures that ought to be adopted for reducing the persisting risks and preventing the occurrence of accidents.

Session 1: Safe Use of Agrochemicals

Harmful effects of agrochemicals

Chemical hazards in agriculture are related to the dangerous pesticides being used, as well as in the maintenance of plant protection equipment and spraying of pesticides. It has been reported by WHO that there are three million cases of agrochemical poisoning with up to 20,000 reported (unintentional) deaths in a year in developing nations. The term 'pesticides' is indeed a non-specific and broad term, and includes as diverse a group of chemicals as herbicides, fungicides, insecticides, nematicides, rodenticides, molluscicides, acaricides, plant growth regulators, and chemical fertilisers commonly used in agriculture.

Some of these pesticides can be harmless, while others can cause severe to very severe damage to the central nervous system, kidney, or increase the risk of cancer. Initial symptoms may be variable and misleading such as muscular weakness, headache, dizziness, and nausea. Continuous use of certain agrochemicals, especially pesticides with which our body comes in contact or is exposed to, results in long term damage to organs like kidney, liver, or the nervous and the endocrinal system inside our body.

Pesticides must not be found in food products but may be present due to the following reasons:

- indiscriminate and extensive use of chemical pesticides.

- Non-observance of prescribed safety norms
- discriminate or indiscriminate sourcing leading to the use of unsafe or sub-standard pesticides.
- wrong advice and supply of pesticides to the farmers by vendors of agrochemicals
- leakage or lack of care in disposal of agrochemicals or its waste by-products by manufacturers
- unclean or improper maintenance of the premises of agrochemical manufacturing area.
- unclean or improper maintenance of the premises of agrochemical storage and preparation area by farmers.
- not using appropriate apparels necessary for the personal safety of the field operators and other such factors.

Methods of safe use of pesticides

Use of safety procedures

Individuals who handle and use pesticides should review safety procedures on a regular basis. These are generally exhibited on the pesticide container labels or in the literature provided with the market product.
Some important do's and don'ts:

- do not ignore, read, and follow the label information and directions.
- while working with hazardous products, do wear a clean personal protective equipment (PPE).
- remove your contact lenses before handling the pesticides.
- wash the hands after you have handled or have had a contact with a pesticide, especially and more so, before eating, drinking, smoking, or using the toilet.
- remove and wash off the contaminated clothing and any spilled pesticide on a person.
- shower and wash the hair and clean the underside of fingernails at the end of each day.
- take proper care with respect to the pesticide as per toxicity labels marked on the pesticide packing.

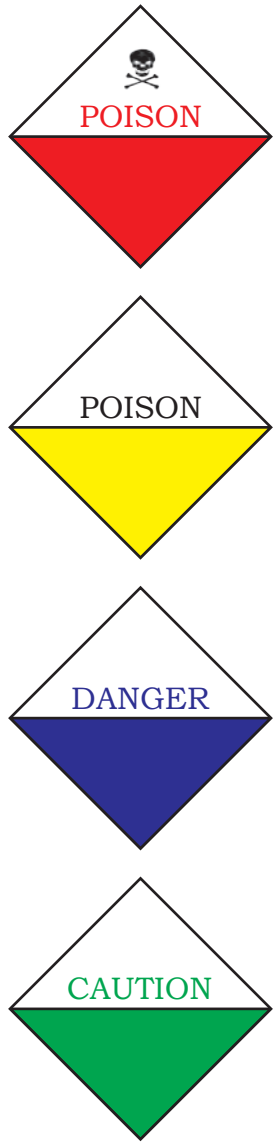


Fig. 6.1: Labels of colours showing toxicity of pesticide

Selecting and buying right pesticides and in required quantity

Safety begins with choosing and buying a pesticide as per one's need only. Check out the following before buying a pesticide:

- Label shows the pesticide as approved for the intended use.
- The pesticide can be used in an integrated pest management programme.
- Purchase just as much as is needed by carefully calculating on the basis of cropped or storage area to be covered.
- Read and follow the instructions that come with the agrochemical.

Fig. 6.2: Safety apparel for preparing spray solutions

Protecting oneself while using the equipment

Several articles of personal dressing or covering are essential while using hazardous chemicals or working with powered machines, viz., rubber gloves, respiratory guards or filters, full overalls but not loose fitting (with missing buttons or zips), etc.

Safety protocol for mixing or applying a pesticide

- Pesticides should be mixed and used at prescribed or recommended rates.
- Use pesticides under favourable weather conditions only; avoid bad weather.
- Don't use muddy or unclean water for mixing with pesticide and for personal clean up.
- Whenever handling the pesticides, clean water tanks should be kept nearby.
- Never smoke or eat in between or while mixing or applying pesticides.
- Some pesticide products are flammable. Take care against fire breaking out due to smoking or any other use of matchsticks or fireplace.

- Read and follow the instructions on the user guide or label properly.
- Use correct pesticide for the pest or disease for which it is meant.

Use the recommended dose and quantity only

- For preparing the aqueous solution of the pesticide, use outdoor open space.
- Use the recommended amounts and dilutions strictly.
- Do not prepare more than the required amounts for field application on a given day only; never try to store for possible future use.

During application of pesticide

- Don't undertake the task of pesticide spraying on a windy day.
- Position yourself in a way that the wind drift blows pesticide spray (or dust) away from your face.
- Before indoor spraying, close the doors and windows of hall or home.
- During the spray operation, keep the nozzle close to the target plants to avoid waste of solution caused by drifting.
- Spraying excess quantity will be wasteful and leave residual harmful amounts on the produce, which if consumed, will be detrimental to the health of the consumer.

Fig. 6.3: Caution signage while pesticide spraying

While preparing the spray solution of pesticide, try to stay away from an open well used to draw drinking water.

Cleaning and disposal of empty pesticide containers

Pesticide containers should be cleaned when emptied, removing the pesticide residues before they dry. Keep the following points in mind while emptying a pesticide container:

- For liquids, transfer the pesticide into a spray tank or mixing tank. Let the last drop

Fig. 6.4: Signage for pesticide applied at field

get emptied. Use a strong nozzle to triple rinse or pressure rinse the metal, plastic, or glass containers, unless otherwise instructed on the label.

- Likewise, for solids, gently shake the bag into tank or hopper until no loose foggy dust is visible. Gently rinse the bags once if possible, unless otherwise instructed on the label.

Pesticide Disposal

Disposal of Concentrated Pesticide

Planning your pesticide purchases will minimise the excess pesticide concentrates left over after an application or use in one season. Review the records of prior applications. Use the pesticide that is on hand before buying more. Contact the pesticide manufacturer or a local vendor to be sure that the old stocks are still effective.

It is best to prepare just the right quantity of pesticide concentrate or solution to avoid disposal problems. It is safer to prepare less quantity rather than preparing excess, which may have to be disposed off unsafely.

Unopened containers may sometimes be returned to the manufacturer or local dealer. Applicators can also contact the pesticide regulatory body for advice on proper disposal of unused pesticides. If excess quantity is left in storage, either use it yourself or let a neighbouring farmer use it, if possible.

Don't stockpile — buy and use as per need. If you have to store the pesticides, keep it out of reach of children. Do lock all the pesticides in a cabinet in a well-ventilated utility area or farm shed.

Disposal of Surplus Prepared Mixture

- 'Prevention is better than cure' has to be the guiding principle for pesticide use.
- accurately measure the area to be treated.
- confirm the application rates of agrochemicals.
- calibrate the application equipment.
- Use all the solution or dispose it off safely.

First-Aid, Treatment and Safety Equipment

Accidents might happen in spite of all the precautions and care. It is essential for students to know about the immediate medical aid for a chemical accident, and to learn about the safety devices needed to prevent accidents.

Chemical Poisoning and First-Aid Measures

Chemical poisoning may result from continuous contact or absorption through skin, inhalation of toxic vapour or swallowing it directly. Common symptoms of pesticide poisoning are headache, nausea, vomiting, tremors, convulsion, and difficulty in respiration. A first-aid kit with necessary antidotes should be available at the work site for each type of poisoning. Antidotes are always mentioned on the pesticide containers.

Treatment for simple chemical poisoning

Swallowed poison

If the poison has been swallowed, induce vomiting immediately. Mustard oil or table salt in a glass of warm water is good for this purpose. Touching the throat internally with finger will also induce vomiting. Vomiting process should be continued till a clear liquid starts coming out of the stomach. If the patient goes into convulsions or in unconscious state, vomiting should be induced. If the poison is due to ingestion of mercury compounds, egg white and milk should be given first, and then vomiting should be induced. At the end of inducing vomiting, soothing substances like raw egg white (mixed with water), butter, or cream milk must be given.

(i) Skin contamination

Contaminated clothes may at once be removed. Contaminated skin should be washed with soap and water and also flushed with plenty of water to reduce the extent of injury.

(ii) Eye poisoning

Eyes of the victim maybe washed with plenty of water, keeping the eyelids open. A quick decisive action is desirable as a delay of a few seconds may greatly increase the extent of the injury. Refer to an eye doctor immediately.

NOTES

(iii) Inhaled poison

The victim of inhaled poison must be immediately exposed to an open area with fresh air. Keep the patient quiet as far as possible. Provide a blanket to avoid chilling. If breathing stops, artificial respiration technique through mouth maybe used.

Safety and protective devices

Protective and safety devices will minimise the chances of a major accident. The protective and safety equipment essentially include a gas mask, hand gloves, shoes, eye shields, headgear, protective clothing, respiratory devices, etc.

Gas mask

It is a device to protect the eyes and respiratory tract from toxic gases, and aerosols. It gives clean air to the operator by removing contamination from the ambient air by using a filter or bed of absorbent material.

Fig. 6.5: Hand-gloves and headgear

Hand gloves

Always use rubberised waterproof gloves, not ones made of leather, cotton, or any fluid-absorbing material.

Shoes

The shoes made of rubber or any synthetic waterproof material are used instead of leather or canvas shoes.

Eye shields

These must be worn to prevent eye poisoning.

Fig. 6.6: Protective clothing

Protective clothing

The skin should be protected by wearing an apron while working with treated crops. Wash clothing before reuse.

Health and safety awareness in the workplace

- Encourage seniors to keep an eye on those working at the workplace.
- Use charts and visuals to demonstrate commitment to health and safety.

- Encourage safe work practices while discouraging unsafe work practices.
- Even at the cost of repetition, communicate that safety is of prime importance while at work.
- Those new to undertaking spray or pesticide application, must be supervised or advised to report immediately about any adverse development concerning the health of the operator.
- Respond and act promptly to all health and safety concerns.
- Set an example in the use of all preventive and protective materials and practices.
- Keep young trainees away from operational area, or supervise them personally to ensure that they do not come close to a working machinery or handling devices and equipment which they are not yet trained to use.

Amenities and environment

- Train all workers rotationally in the use of first aid equipment and provide first-aid kits at easily accessible points.
- Insist on first-aid training for all the field workers.
- There should be free access to washroom and toilet facilities with running water or stored clean water.
- There should be free access to potable, clean, and cool drinking water.
- As far as possible, take steps to prevent the entry of poisonous creatures like scorpions, snakes, leeches, etc.
- Don't keep flammable materials in large quantities or in easily approachable or accessible areas prone to fire hazard.

Emergency response

- Train a task force for emergency response action for the workplace (for example, snakebite, fire, confined space entry, heat stress, or chemical spill).
- Keep safety awareness level of workers high at all times.
- Maintain emergency response equipment.

NOTES

Manual tasks for personal safety

- Use appropriate restraint systems when and where required.
- Take care to avoid crush injuries to hands.
- Use aids to lift or move down the injured animals when and where possible.
- Try and minimise the risk of slips, trips and falls; provide non-slip flooring.

Practical Exercise

Activity 1

Demonstration of safety devices and measures to be followed

Material Required

First-aid kit, gas mask, protective clothing, eye shields, hand gloves, shoes, and pictorial charts.

Procedure

- Identify the different types of protective devices used while handling and applying the chemicals.
- Understand their use through pictorial charts.
- Identify and understand about each item and its uses.
- Discuss the different types of chemical poisoning and its immediate symptoms.
- Demonstrate the use of different protective devices.
- Prepare a chart showing different protective devices and their use.

Check Your Progress

A. Fill in the Blanks

1. To induce vomiting, _____ can be used.
2. Contaminated skin must be _____.
3. To protect eyes and respiratory tract from toxic gases, _____ is used.
4. Hand gloves made up of _____ are used to handle chemicals.
5. For inhaled poison, first-aid can be_____.

B. Multiple Choice Questions

1. Common symptoms of pesticide poisoning are:
   (a) Headache (b) Vomiting and nausea
   (c) Difficulty in respiration (d) All of these

2. To prevent hazards at working place, availability of following materials should be ensured:
   (a) SDS (b) First-aid kits
   (c) Protective clothing (d) All of these
3. Emergency services comprise _____.
   (a) Ambulance (b) Fire brigade
   (c) Both (a) and (b) (d) None of these
4. Potential dangerous creatures around house and office buildings include _____ .
   (a) lizards (b) snakes
   (c) spiders and scorpions (d) All of these
5. What safety measures are required during the application of pesticides to the crop?
   (a) Mixing the correct quantity of pesticide and clean water, and spraying during evening time
   (b) Use of any type of nozzle and spray mixture
   (c) Spraying of insecticides with flat nozzle against the direction of wind
   (d) Spraying at any time during the day
6. What safe pesticide handling practices are required to be followed by the farmers?
   (a) Wearing clean personal protective equipment (PPE)
   (b) Wash hands with clean water before doing any activity which involves food intake or use of area around mouth, eyes, nostrils, etc.
   (c) If an insecticide or its solution happens to fall on the clothing or body of an individual, give a proper wash to remove the pesticide completely.
   (d) All of the above

C. Subjective Questions

1. What are the first aid treatment measures for chemical poisoning?

   _____

   _____

   _____

2. What protective devices are meant for protection in the agricultural field?

   _____

   _____

   _____

3. Define agro-chemicals.

   _____

   _____

   _____

NOTES

4. Discuss the various harmful effects of agro-chemicals.

_____

_____

_____

_____

D. Match the Columns

A	B
1. Eye	(a) Rubber
2. Shoe	(b) Shield
3. Protective clothes	(c) Apron

SESSION 2: SAFE USE OF AGRICULTURAL MACHINERY

Agricultural field operations today are dependent on various agricultural machinery, tools, and equipment. Use of machinery demands great care with all the necessary safeguards.

The accidents associated with agricultural machineries are caused due to the following reasons:

- lack of adequate or proper training to operators
- poor maintenance of tools and machinery
- using a machine that is not right or suitable for the task at hand
- failure in following proper norms of a safe system of work
- missing or defective safety devices or machine guards, thus exposing the workers to accidents
- unsafe methods for clearing blockages on the premise

Checking the tools and machinery before use

Before starting to work with a tool or machinery, one must make sure that it is in a good working condition and safe to use. While specific needs would vary with the machine to be used, basic checks must always be adopted and exercised:

- Check the operator manual of the machine for pre-operative instructions and follow them as advised.
- Particular attention is warranted to items like brakes, wheels, moving parts of machine (if openly visible) and tires of tractors or vehicles.
- Make sure that the guards and protective covers are securely positioned so that these would not come out loose.
- Promptly repair or replace the defective or damaged parts of machine, if any.
- Stopping devices should be functioning correctly, for example, brakes, emergency stops (electric switches), etc.
- While coupling, engaging or attaching equipment or a part with the machines, make sure that the coupling or attachment is properly fit and is of appropriate size or specification and is not loose. Don't use wrong or makeshift coupling devices and pieces.
- Vehicles and moving machines must have clear rear view mirrors along with fit, fine and properly working reversing aids.
- If the guards over moving parts of a machine are missing, get them fitted out and properly covered before using the machine.

Daily or periodic mandatory inspection for the use of machinery

1. Check water, fuel, fan belts, etc.
2. Inspect the hydraulic lines for kinks, cracks and general wear and tear.
3. Once the engine is running, check hand and air brakes, this ensures that the brakes will hold while loading.
4. Inspect the cracks in the metal which may cause equipment to break or the parts come off unexpectedly.
5. Keep a safe distance from the equipment when loading or unloading.
6. Take care if there are any overhead power lines, particularly during loading and offloading, or while lift-removing of the produce or materials.

NOTES

7. Do discuss any unsafe actions that come to the notice of supervisors so that preventive measures can be taken.

Guidelines to avoid accidents and enhance safety while working with harvesting and threshing machinery

- Familiarise yourself with safety risks and measures to overcome the same.
- Harvesting and threshing machines are most prone to debilitating accidents, *viz.*, crushing, cutting, seizing of body parts, especially hands, feet and trunk. Caution the operators accordingly.
- During field operations with moving vehicles, machinery with moving parts, handling the moving part of a machine, always ensure to wear tight clothing and hair cover to avoid entanglement.
- Never clean, maintain, adjust or clear jams when the machine is on.
- Stay clear of outlets, discharges, and all moving parts of the machine.
- If an equipment breaks down, don't just improvise it, get it repaired.
- Avoid coming close to the moving parts of a powered machine
- Never leave a machine with the engine running.
- Don't let children come near a machine while at work.
- Don't refuel a machine with engine running.
- Don't let flammable articles or substances (like fuel, straw, etc.) close to the working area or machine in operation.
- Do not oil, grease, or adjust the machine during operation. Wait for the engine and moving parts to come to a full stop before doing this. Remember, the feeding area of a thresher is the most dangerous. Do not let your hand or a loose sleeve of shirt enter the feeding area of a thresher.
- Completely avoid working on a petrol or diesel driven machine in a closed shed or garage. Exhaust fumes are dangerous for your health.

Protective measures during operating machinery

Use of protective clothing is an extra measure of protection. All workers operating the machines must wear protective clothing or personal protective equipment as a protection against accident or hazards. Also, make sure that the protective dress is safe and body fitting (not loose or with loose ends). Features of protective dress and equipment:

- good fit, appropriate, and clean or well maintained.
- safe and preventive storage to avoid damage, cuts and insect infestation
- no rough edges
- overall body coverage using overalls, aprons, vests, socks, and gloves
- prevent noise pollution while at work.
- hard hats are always desirable for head protection.
- make sure protective clothing is available for different parts of the body.
- clothes must be kept clean, fully functional, and sanitised.

Practical Exercise

Activity 1

Demonstrate general inspection for the use of machinery.

Material required

Different types of equipment, user's guide, pen, and notebook

Procedure

- Identify and select the machinery.
- Check the different parts of machinery.
- Identify the open moving parts or feeding parts which pose hazard.
- Check assembling of each part of the equipment.
- Demonstrate the use of machinery after inspection.

Check Your Progress

A. Fill in the Blanks

1. During harvesting, ensure that the operators wear _____, and secure their_____to avoid entanglement.

NOTES

2. Nobody should be allowed to _____ onto the machine while it is in motion.
3. Operators must wear_____clothing.

B. Multiple Choice Questions

1. What is necessary to check before starting the machinery?
   (a) Farm operations
   (b) Fill the fuel
   (c) Check the tires
   (d) Check the lights
2. What type of care is required to avoid any machinery accident?
   (a) Using a machine that is unsuitable for the task
   (b) Using casual approach for operation
   (c) Working with missing or defective guards and other safety devices
   (d) Following all the precautions during the operation.
3. Which of the following safety precautions are necessary while refueling of tractor or any other machinery?
   (a) Engine in running condition
   (b) Engine in off position
   (c) Engine in off position and no open flame nearby
   (d) All of these

C. Subjective Questions

1. Enlist the general inspection points to be observed before using the machinery.

   _____

   _____

   _____

2. Describe the health and safety points to be followed during combine harvesting.

   _____

   _____

   _____

3. Describe the use of protective clothing during machinery operations.

   _____

   _____

   _____

Glossary

Acclimatisation: *it is the practice of withholding water a day or two before the actual transplanting operation to harden the seedlings.*

Annuals: *annuals are those plants which grow from a seed, flower and die within one year or one season.*

Antagonism: *the mechanism of limiting or controlling the growth of a microorganism through another microorganism is called antagonism.*

Aphids: *these are clustering creatures which suck the cell sap from young and tender plant parts, especially both the sides of tender leaves, shoot tips, buds and flowers.*

Arches: *arches are semi-elliptical or rectangular metallic entrances made over cemented pillars or walls and covered cum trained with beautiful climbers.*

***Asokavanam*:** *it was a place or garden where royal ladies like queens and princesses used to relax.*

Balance: *it is the equalisation of visual weight from one area of a landscape composition to the other area.*

Bio-control or biological control: *when some living organisms (parasites or predators such as birds, rodents) or certain plant products are used to control the pests of a crop, it is called bio-pesticide, and the method is known as bio-control or biological control.*

Bio-fertilisers: *these are microorganisms which add, conserve and stimulate plant nutrients in the soil, some fixing atmospheric nitrogen symbiotically, and some convert insoluble phosphates to soluble phosphates in the soil.*

Bio-herbicides: *living organisms such as fungi, bacteria and insects are used to control weed population. Such herbicides are broadly known as bio-herbicides.*

Bird bath: *it is a bowl-shaped ornamental container which is filled with ample fresh water and kept at a quite elevated place for inviting birds in the garden.*

Cacti: *these are members of the cactaceae family with peculiar shape and size, and adapted for desert life.*

Carpet bedding: *it is planting of dwarf herbaceous plants in a bed or series of beds according to a set design.*

Climbers: *those plants which have special structures to climb on support for sunlight and air are defined as climbers.*

Creeper: *plants which are too weak to rise vertically above the ground on their own. Produce cluster of roots from the nodes which clasp on support as the shoots grow up.*

Depotting: *it is the removal of plants from pots for planting in the pot, soil or bed.*

Deshooting: *it is removal of all the side shoots (offshoots or offsets) emerging from the base of the plant.*

Dibbling method: *it is a method of planting well-matured rooted or unrooted grass cuttings obtained from a close cut lawn or nursery for the establishment of a lawn.*

Dip method: *here cuttings before planting are dipped in the fungicidal solution for certain period.*

Disbudding: *it is the removal of floral buds when a large flower on a plant is desired.*

Disease: *any abnormality occurring in a plant due to pathogen is called a disease.*

Drainage: *drainage is the process of removing water from the soil that is more than the need of crop plants.*

Drip irrigation: *it is a drop by drop, slow but continuous watering directly to the root zone of the plant with full economy of water.*

Dust: *it is a dry formulation of pesticide with an inert carrier.*

Earthing up: *it is the technique in horticulture where soil is piled up around the base of a plant.*

Edge plants: *They are evergreen, low growing plants (20–25 cm), grown on the border of plot.*

First-aid: *assistance given to any person suffering from a sudden illness or injury.*

Floating plants: *these plants don't need hold or grip of soil (anchorage) for their survival.*

Floral clocks: *this is a huge clock operating by electricity having huge hands for showing the seconds, minutes and hours.*

Form: *it is a broad term showing two or three-dimensional structure and shape of an object or space.*

Galls or hypertrophied structure: *it refers to abnormal plant growth caused due to the infestation of insects and mites.*

Garden: *a garden is a planned space, indoors or outdoors, set for the display, cultivation and enjoyment of plants and other forms of nature.*

Green manure crops: *these are those crops which are knocked down in the field for decomposition just before the stage of maturation, such as sunnhemp or dhaincha.*

Hardy annuals: *they do not require artificial aid for their growth and flower freely in the open.*

Hedge plants: *the plants used for hedge making are called hedge plants.*

Hedge: *shrubs or small trees planted at regular interval to form a thick continuous screen is called a hedge.*

Herbaceous perennials: *these are those ornamental plants which have soft and succulent stems, and bear flowers year after year.*

Insects: *insects are the organisms belonging to division Insecta of animal kingdom, with three pairs of legs and two pair of wings.*

Integrated disease management (IDM): *it is the integration of various methods used for avoiding and controlling the diseases.*

Integrated weed management (IWM): *it involves the utilisation of both preventive and curative measures (exclusion, physical, cultural, chemical and biological methods) in well planned way for weed control.*

Irrigation: *replenishing the soil water deficit by applying water to the crop is called irrigation.*

Landscape gardening: *it is an aesthetic branch of horticulture which deals with the planting of ornamental plants in such a way that it creates a picturesque effect.*

Landscaping: *landscaping is the art of beautifying a piece of land using garden designs, methods and plant materials.*

Lawn: *a lawn can be defined as the green carpet for a landscape.*

Legislative method (Quarantine): *this is a method of preventing the introduction of new insect-pests from the exporting countries.*

Macronutrients: *those essential nutrient elements which are required in large quantity by the plants.*

Marginal plants: *these plants keep their roots in shallow water and aerial parts above the surface.*

Mites: *these are minute, yellow, rusty-green, red, black or brown spider-like eight legged creatures.*

Modern, picturesque, artistic or free type of gardening: *in this type of gardening, best features of both formal and informal types are selected to secure the most picturesque effect.*

Mowing: *it is the process of cutting down lawn grass with the help of a mower as grass in the lawn should not be allowed to grow more than 5–7 cm in height.*

Mulching: *it is the act of applying a 5–10 cm thick layer of covering material on the ground surface around the growing plants.*

Myco(fungi) herbicide: *when fungal spores or fungi are used to control the weeds, this is known as myco(fungi) herbicide.*

***Nandanavana*:** *special gardens dedicated to Lord Krishna with water pools studded with lotuses and lilies.*

Non-selective: *these are the herbicides that prove lethal to almost all the monocots and dicots that come in their contact.*

Nutrients: *nutrients are the chemical elements which are absorbed by plants in small or large quantities to transform light energy into chemical energy for the synthesis of organic materials.*

Nutrition: *the essential nutrients required for normal metabolic activities in the body of an organism or plant is known as nutrition.*

Occupational hazards: *hazards experienced at the workplace.*

Oxygenators: *these are oxygenating plants which maintain hygiene and balance in a pool, and therefore are vital to any pool.*

NOTES

Perennial weeds: *these weeds complete their life cycle in more than two years.*

Perennials: *these are woody or non-woody plants which grow for more than two years.*

Pergola: *it is a series of arches joined together and covered with shading material or plants.*

Pinching (stopping): *it is the removal of growing tips of the terminal portion of plants to promote bushy growth for more lateral formation and precocious flowering.*

Post-emergence herbicides: *these are the herbicides which are applied after weeds have emerged.*

Potting: *potting refers to the planting of seedlings, polybag plants or any other plant uprooted from soil or growing media in pots containing potting mixture.*

***Pramododyan*:** *it was a private garden for kings and queens exclusively.*

Pre-plant herbicides: *this is a group of herbicides applied before planting the main crop.*

Pricking: *the operation of transferring the young seedlings to another bed, pan or tray for better space, nutrients and light is called as pricking.*

Rambler or straggler: *it has neither special structure to climb up the support nor it coils around the support, but it climbs on its own.*

Repetition: *it is the use of an element in a design more than once in order to maintain unity, establishing rhythm and sequence, and pulling whole of the design together.*

Scrambler: *a plant that produces long weak shoots by which it grows over other plants.*

Selective herbicides: *these are the herbicides used against specific group of weeds, and do not prove harmful for other crops.*

Shrub: *a shrub is a woody or semi-woody perennial plant with little or no trunk and grows up to a height of 50 cm to less than five meters.*

Shrubbery border: *area of the garden devoted exclusively for growing shrubs planted in a row or in rectangular fashion.*

Side dressing: *It refers to the fertiliser being placed beside the rows of a crop (widely spaced), like maize or cotton.*

Soil drenching: *application of fungicide or nematicide to the soil for controlling soil-borne infection of fungi (wilt, damping off, root rot) or nematodes (root-knot).*

Solarisation: *it is the method of increasing soil temperature through absorption of sunlight, so that it destroys the seeds and other propagules of weeds, vis-à-vis harmful pathogens and insect-pests present in the soil.*

Sprinkler irrigation: *it is aerial watering of the crop or field with pressure through revolving sprinkler nozzles by the pipes fitted with*

stand. The nozzles revolve due to pressure of water and spread water in the form of thin spray.

Staking: *it is a practice to support the plants for growing straight and saving them from bending or lodging.*

Sub-shrub: *the plant whose basal portion is woody and the upper shoots are soft is called a sub-shrub.*

Succulents: *these are those plants which possess fleshy foliage or stems or both.*

Topiary: *the art of clipping and shearing climbers, shrubs, small trees and herbaceous perennials into various artistic shapes.*

Trailers: *these plants are like creepers but they lack the ability to root at their nodes.*

Transplanting: *transplanting is the operation of lifting the seedlings from nursery beds or pots and planting them to the permanent place already prepared.*

Turf: *turf is a piece of earth of about 5 cm thickness and 30 cm width with grass thickly grown over it.*

Turfing: *turfing is a method of using different turves and placing them in a well prepared soil like bricks in a wall.*

Twiner: *it is a plant which does not possess special structures to climb up the support but climbs by spiralling or coiling.*

NOTES

Further Readings

Arora, J.S. 2008. *Introductory Ornamental Horticulture*. Kalyani Publishers, New Delhi.

Atwal, A.S. and G.S. Dhaliwal. 2002. *Agricultural Pests of South Asia and Their Management*, Kalyani Publishers, New Delhi.

Biswas, T.D. and S.K. Mukherjee. 2008. *Textbook of Soil Science*. Tata McGraw-Hill, New Delhi.

Farmer's Handbook on Basic Agriculture. 2016. MANAGE, Hyderabad. pp. 121–130.

Gupta, O.P. 2011. *Weed Management*: *Principles and Practices*, Agrobios Publications, Jodhpur, India.

Handbook of Agriculture. 2013. ICAR, New Delhi.

Jagtap, G.P., Dhutraj D.N. and Utpal Dey. 2012. *Diseases of Horticultural Crops and Their Management*. Agrobios Publications, Jodhpur, India.

Singh, Jitendra. 2011. *Introduction to Horticulture*. Kalyani Publishers, New Delhi.

Pradhan S. 2007. *Insect Pests of Crops*. National Book Trust, India.

Randhawa, G.S. and A. Mukhopadhyay. 1986. *Floriculture in India*, Allied Publishers, New Delhi.

White, G. 1989. Occupational Hazards of Farming. *Can Fam Physician*, 35: pp. 2331–2336.

Answer Key

Unit 1: Cultivation of Commercial Flower Crops—I

Session 1: Cultivation of China Aster

A. Fill in the Blanks

1. sandy loam, 6.8–7.5
2. 10–15, 120:80:120
3. garlands and worshipping
4. seed
5. 2.5–3.0

B. Multiple Choice Questions

1. (a) 2. (d) 3. (c) 4. (b) 5. (a)

D. Match the Columns

1. (d) 2. (e) 3. (a) 4. (b) 5. (c)

Session 2: Cultivation of Chrysanthemum

A. Fill in the Blanks

1. hand removal, 10–15 cm
2. fully open, central disc
3. queen of East or Autumn Queen
4. pompon and decorative
5. suckers and terminal

B. Multiple Choice Questions

1. (a) 2. (b) 3. (c) 4. (d)
5. (a) 6. (b)

D. Match the Columns

1. (b) 2. (a) 3. (c) 4. (d)

Session 3: Cultivation of Tuberose

A. Fill in the Blanks

1. bulbs and bulblets
2. 2–3
3. 15–30
4. 3 to 4
5. spindle

B. Multiple Choice Questions

1. (d) 2. (a) 3. (a) 4. (b) 5. (c)

D. Match the Columns

1. (g) 2. (f) 3. (e) 4. (d) 5. (c)
6. (b) 7. (a)

Session 4: Cultivation Technique of Gladiolus

A. Fill in the Blanks

1. Gladiolus
2. corms or cormlets
3. 1000
4. 7–15 cm
5. single and 1–3
6. length

B. Multiple Choice Questions

1. (d) 2. (a) 3. (a) 4. (b) 5. (a)

D. Match the Columns

1. (d) 2. (c) 3. (b) 4. (a)

Session 5: Cultivation Technique of Carnation

A. Fill in the Blanks

1. disbudding
2. pinching
3. terminal cuttings
4. 3 × 3 cm
5. 10–15 cm

B. Multiple Choice Questions

1. (a) 2. (b) 3. (c) 4. (b)

D. Match the Columns

1. (c) 2. (e) 3. (a) 4. (b) 5. (d)

Session 6: Cultivation Technique of Gerbera

A. Fill in the Blanks

1. Republic of South Africa
2. division of clumps and cuttings
3. October
4. 50–70
5. 150–250

B. Multiple Choice Questions

1. (a) 2. (b) 3. (d) 4. (c)

D. Match the Columns

1. (d) 2. (c) 3. (b) 4. (a)

Unit 2: Cultivation of Commercial Flower Crops—II

Session 1: Cultivation of Rose

A. Fill in the Blanks

1. 11
2. C
3. three
4. Floribunda
5. Grandiflora
6. Polyantha
7. miniatures
8. rose balling
9. Blindshoot

B. Multiple Choice Questions

1. (a) 2. (a) 3. (a) 4. (a)
5. (b) 6. (b) 7. (a)

D. Match the Columns

1. (b) 2. (a) 3. (d) 4. (e)
5. (c) 6. (f)

Session 2: Cultivation of Gaillardia

A. Fill in the blanks

1. Blanket flower
2. bedding or borders
3. seeds
4. 31 months
5. 10 days
6. 90, 120

B. Multiple Choice Questions

1. (b) 2. (a) 3. (d) 4. (a)
5. (c)

D. Match the Columns

1. (d) 2. (c) 3. (b) 4. (a)

Session 3: Cultivation of Marigold

A. Fill in the Blanks

1. *Tagetes patula*
2. Asteraceae

NOTES

3. root-knot nematodes
4. tip cuttings
5. seeds
6. 0.7–1.0

B. Multiple Choice Questions

1. (d) 2. (a) 3. (c) 4. (a)
5. (b) 6. (d)

D. Match the Columns

1. (b) 2. (a) 3. (d) 4. (c)

Session 4: Cultivation of Jasmine

A. Fill in the Blanks

1. 20%
2. *Jaminum grandiflorum*
3. simple layering and stem cuttings
4. winters
5. cuttings
6. rainy season
7. 8–10

B. Multiple Choice Questions

1. (a) 2. (b) 3. (b) 4. (b)

D. Match the Columns

1. (d) 2. (a) 3. (b) 4. (c)

Session 5: Cultivation of Crossandra

A. Fill in the Blanks

1. firecracker plant
2. Lakshmi
3. 2.0–2.5 kg
4. ground layering
5. 70–75 days
6. ethylene

B. Multiple Choice Questions

1. (c) 2. (a) 3. (b) 4. (c)
5. (b) 6. (a)

D. Match the Columns

1. (b) 2. (a) 3. (e) 4. (d) 5. (c)

Unit 3: Growing of Annuals

A. Fill in the Blanks

1. annuals
2. winter season
3. September–October
4. summer season
5. rainy season
6. June
7. Herbaceous border
8. irrigation
9. damping off
10. pro-trays

B. Multiple Choice Questions

1. (a) 2. (b) 3. (c) 4. (b) 5. (c)
6. (d)

D. Match the Columns

1. (e) 2. (d) 3 (c) 4. (b) 5. (a)

Unit 4: Growing of Perennials

Session 1: Trees, Shrubs and Vines

A. Fill in the Blanks

1. perennial
2. perennial herbs
3. weak stem
4. shrubs
5. tree
6. five
7. evergreen trees

B. Multiple Choice Questions

1. (a) 2. (a) 3. (c) 4. (c) 5. (c)

D. Match the Columns

1. (d) 2. (e) 3. (c) 4. (a) 5. (b)

Session 2: Indoor Plants

A. Fill in the Blanks

1. house plant
2. palms
3. July–August

4. shallow pan, planting
5. Penzai

B. Multiple Choice Questions

1. (b) 2. (a) 3. (d) 4. (d)

D. Match the Columns

1. (a) 2. (c) 3. (d) 4. (b)

Unit 5: Post Harvest Management and Value Addition

A. Fill in the Blanks

1. perishable
2. 30–40%
3. cool hours
4. demineralised water
5. respiration
6. pulsing
7. sugar
8. grading
9. garlands
10. gulkand

B. Multiple Choice Questions

1. (d) 2. (d) 3. (a) 4. (b) 5. (d)
6. (c)

D. Match the Columns

1. (d) 2. (c) 3. (b) 4. (a)

Unit 6: Maintain Health and Safety at the Workplace

Session 1: Safe Use of Agrochemicals

A. Fill in the Blanks

1. table salt and mustard oil
2. washed with soap
3. gas mask
4. rubber
5. artificial respiration

B. Multiple Choice Questions

1. (d) 2. (d) 3. (c) 4. (d) 5. (a)
6. (d)

D. Match the Columns

1. (b) 2. (a) 3. (c)

Session 2: Safe Use of Agricultural Machinery

A. Fill in the Blanks

1. tight clothes, hair
2. climb
3. protective

B. Multiple Choice Questions

1. (c) 2. (d) 3. (d)

NOTES

List of Credits

Fig. 1.1; Fig.2.2; Fig. 3.3; Fig. 3.6; Fig. 3.7; Fig. 3.9; Fig. 3.10; Fig. 3.12; Fig. 3.13; Fig. 3.14; Fig. 4.1; Fig. 4.2; Fig. 4.3; Fig. 4.4; Fig. 4.5; Fig. 4.6; Fig. 4.7; Fig. 4.11; Fig. 4.12; Fig. 4.13; Fig. 4.14; Fig. 4.16; Fig. 4.17; Fig. 4.19; Fig. 4.20; Fig. 4.21; Fig. 4.22; Fig. 4.24; Fig. 4.26; Fig. 4.27; Fig. 4.28; Fig. 4.30; Fig. 4.31; Fig. 4.32; Fig. 4.33; Fig. 4.34; Fig. 4.39; Fig. 4.40; Fig. 4.41; Fig. 4.42; Fig. 4.44; Fig. 4.45; Fig. 4.46; Fig. 4.47; Fig. 4.48;
Courtesy: Professor R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.2: Courtesy: http://tinyurl.com/yxqwj6r3

Fig. 1.3; Fig. 1.4; Fig. 1.5; Fig. 1.6; Fig. 1.7; Fig. 1.8; Fig. 1.9
Courtesy: Dr. Manish Kapoor, Associate Professor (Botanical Gardens) Department of Botany, Punjabi University, Patiala, Punjab

Fig. 1.10: Courtesy: http://tinyurl.com/y4pxh6fe

Fig. 1.11: Courtesy: http://tinyurl.com/y2c3jfo6

Fig. 1.12; Fig. 3.2; Fig. 5.1; Fig. 5.2 (a, b, c)
Courtesy: Balaji Shreedhar Kulkarni, Professor and Head, College of Horticulture, UHS, Bagalkot, Bengaluru

Fig. 1.13: Courtesy:https://tinyurl.com/y6nalcav

Fig. 2.1: Courtesy: http://tinyurl.com/y3c8glpc

Fig. 2.3: Courtesy: http://tinyurl.com/y5ykc83x

Fig. 2.4: Courtesy: https://tinyurl.com/y2l99r94

Fig. 2.5: Courtesy: https://tinyurl.com/y58rt6t9

Fig. 3.1: Courtesy:https://tinyurl.com/y2o6js5t

Fig. 3.4: Courtesy: https://tinyurl.com/y44x7jd2

Fig. 3.5: Courtesy: https://tinyurl.com/y59op7et

Fig. 3.8: Courtesy: https://tinyurl.com/yyz8ao5f

Fig. 3.11:Courtesy: https://tinyurl.com/y23emufr

Fig. 4.8: Courtesy: https://tinyurl.com/yxgwccsd

Fig. 4.9: Courtesy: https://tinyurl.com/y3thmxvb

Fig. 4.10: Courtesy: https://tinyurl.com/yyeod86f

Fig. 4.15: Courtesy: https://tinyurl.com/y5zj3wv7

Fig. 4.18: Courtesy: https://tinyurl.com/y49n694q

Fig. 4.23: Courtesy: https://tinyurl.com/y667ulud

Fig. 4.25: Courtesy: https://tinyurl.com/yxsy2dhk

Fig. 4.29: Courtesy: https://tinyurl.com/y27v46uy

Fig. 4.35: Courtesy: https://tinyurl.com/y2ave9b4

Fig. 4.36: Courtesy: https://tinyurl.com/y444g786

Fig. 4.37: Courtesy: https://tinyurl.com/y69wbouy

Fig. 4.38: Courtesy:https://tinyurl.com/y57lscx8

Fig. 4.43: Courtesy: https://tinyurl.com/y4jpcvj3

Fig. 6.1: Courtesy:https://goo.gl/nWpfBV

Fig. 6.2: Courtesy:https://goo.gl/ygxajB

Fig. 6.3: Courtesy:https://goo.gl/uixDC7

Fig. 6.4: Courtesy: https://goo.gl/XzFfqn

Fig. 6.5: Courtesy:https://goo.gl/ZvGFsn

Fig. 6.6: Courtesy:https://goo.gl/mzBA2Q
Narendra Vasure, Consultant (Horticulture), PSSCentral Institute of Vocational Education, Bhopal

Notes

Notes

Notes