Floriculturist
(Protected Cultivation)

(Job Role)

Qualification Pack: Ref. Id. AGR/Q0702
Sector: Agriculture

Textbook for Class XII

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NCERT

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Textbook for Class XII

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Foreword

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricula, 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 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 Education, erstwhile 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
September 2020

About the Textbook

Agriculture is an important part of India's economy. It accounts for about 18 per cent of the country's GDP and occupies almost 43 per cent of India's geographical area. 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-protected cultivation, floriculturist-open cultivation, tuber crop cultivator, micro irrigation technician, solanaceous crop cultivator, etc., are in demand by the States for preparing skilled manpower.

A Floriculturist (Protected Cultivation) is a person who has undertaken various activities of flower cultivation involving preparatory cultivation, cultivation and post-harvest management in a greenhouse. Their responsibilities also involve maintenance and care of plants, design and maintenance of greenhouse, preparing media 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 for higher returns.

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

The textbook has been developed with contributions by subject experts, vocational teachers, industry experts and academicians for making it a useful and inspiring teaching-learning resource material for students of vocational studies. 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 so as 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 (Protected 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 care and maintenance of protected structures. Unit 2 focuses on protected cultivation of rose, gerbera, carnation, lilium and orchids. Unit 3 deals with special horticultural practices in protected cultivation. Unit 4 focuses on the control of insect-pests and diseases in flower crops. Unit 5 deals with harvesting and post-harvest management. Unit 6 focuses on maintaining health and safety at workplace.

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.

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The images used in the textbook have been sourced from the Creative Commons License, Jain Irrigation System Ltd., Naved Sabir, *Principal Scientist*, Centre for Protected Cultivation Technology, IARI, New Delhi and Balaji Shreedhar Kulkarni, *Professor* and *Head*, UHS Campus, G.K.V.K., Bengaluru, Karnataka. They have been selected with care and diligence for clearer understanding of learners. Care has been taken to not violate any copyright. The images are meant for educational purpose and are being provided for the personal use of students and teachers.

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Contents

Unit 1

Care and Maintenance of Protected Structures

Protected structures have two main components, namely structure and covering material. Greenhouse, net house, shade net, nursery, tunnels, etc., are examples of common protected structures.

In greenhouses, components like polythene film, insect proof net, pump, foggers, drip line, filter, control panel, heating system, shade net, etc., are delicate and some items like exhaust fans, pumps, motors, etc., are machine based. If these systems are not maintained from time to time they can get damaged due to mishandling or carelessness. Further, because of poor maintenance, frequent breakdowns are likely, hampering production resulting in losses. To avoid this, we have to properly maintain the various components of greenhouses very carefully.

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Session 1: Care and Maintenance of Protected Structure Components

Maintenance of Protected Structure

Structure

- Check the nuts and bolts of trusses and purlins and if found loose, tighten them.

- Check the nuts and bolts in the main column and foundations, trusses and gutters, and if found loose, tighten them.
- Check the nuts and bolts of motors, cranks and gearboxes.
- Do periodic oiling and greasing of moving parts wherever they are present in the system like gearbox, crank, doors, etc.

Polyethylene film

- Wash polyethylene film with pressurised water flow once in a month during the day for fast evaporation, else algal growth may develop.
- During washing, do not use any brush or blade. Use a hosepipe with pressurised flow of water using cloth, if required.
- During washing, take care of the film to prevent it from tearing.
- If polyethylene sheet is torn by wind, use an adhesive tape (poly repair tape or tape roll) to repair the sheet from the inside and outside.
- Check the nuts and bolts in aluminium profiles, spring and tighten them properly.
- Always use new polyethylene film after 3–4 years of use.
- Avoid dismantling and installation of polyethylene film during windy conditions.
- During the installation of a polyethylene film, stretch it properly and fix one side in locking profiles and later, fix all the other sides in profiles.

Exhaust fan (in case of forced ventilated greenhouse)

- When the fan is on, don't put any materials or hand inside.
- When the fan is on, don't touch the louvers or push them forcefully.
- Oil and grease all the movable machine parts like louvers, bearing, etc., once in a month.

- Always check the nuts and bolts of the fan and its motor.
- Protect the motor from water.
- Periodically check the fan belt and pulley.
- Before starting repair work of the fan, stop electrical supply and check.
- Before starting the fan, after it is repaired, close the GI mesh properly.
- When the fan is being repaired, take care that no one switches it on.
- All the electrical work should be done by a trained or professional electrician only.

Heating and cooling system

- When the fan is on, don't put any materials or hand inside the heating and cooling system.
- The heating and cooling system should be operated only with permission from the incharge.
- Always check the nuts and bolts of the heating and cooling system and its motor.
- Before starting the heating and cooling system, stop the electrical supply and check.
- Do not allow the heating and cooling system to run continuously to avoid burning or melting of the duct.

Side curtains

- Ensure proper lifting of the side curtains using the curtain handles.
- Apply a lubricant, in case the handle is jammed.
- In winter, close the curtains from evening to the early hours of the next morning.
- Close the side curtains, when there are high speed winds, storm or rain, else the greenhouse may get flooded and polyethylene may get torn.

Shade net

- Before the shade net is installed, all the wires should be tightened properly.
- During installation, ensure that the net is not torn.

NOTES

- Don't use any sharp tools to fix the shade net.
- Before fixing the shade net, stretch it from all the sides, not leaving it loose.
- Before dismantling, rolling and storing it in the shade, ensure that there are no cuts or tears.

Motor, pump, control panel and electrical cable

- Use a proper shielded cable for the greenhouse.
- Always check the pumps, motors, etc.
- The pump and motor should be serviced periodically.
- Call the electrician to check the panel.
- Protect the panel from water.
- Only a trained person should operate the panel.
- Follow the instructions of an electrician or engineer.
- A motor, pump, control panel and electrical cable should be ISO/BIS marked.

Precautions to be taken during Care and Maintenance

- The greenhouse should have double doors.
- Both the doors should remain closed.
- Close the doors after entering the greenhouse.
- Keep footwear outside the greenhouse.
- Don't smoke inside the greenhouse.
- Clean hands and feet before entering the greenhouse and workers should not wear bright coloured clothes.
- Don't touch the leaves or parts of diseased plants or use gloves while touching them.
- Ensure there is no water logging in the greenhouse.
- Don't open the side curtains or doors during heavy wind and rainfall or in severe winter.
- Shut off the entire system before leaving the greenhouse (except the heating system in severe winter) in the evening and restart it in the morning.
- Check that the voltage is proper, before starting the control panel. If there are fluctuations in the recorder, check the system properly and use a voltage stabiliser.

- Check the water level in the tanks daily and ensure that they are filled.
- In winter and low light conditions or cloudy days, the shade or silver net inside the greenhouse should be folded back for proper solar radiation.
- Check all nuts and bolts, pipes, drip system, fogging system, sprinkler system, and cable networks inside the greenhouse periodically.

Practical Exercise

Activity 1

Visit a polyhouse or shade net house and find out from the grower about the maintenance activities being carried out.

Material required: Writing material

Procedure

- Visit the site in consultation with the farmer.
- Interact with him and find out the maintenance activities that are being taken up regularly.
- Note down the activities.

Check Your Progress

A. Fill in the blanks

1. _____ is strictly prohibited inside the greenhouse.
2. Oiling and greasing should be done periodically wherever _____ are present in the greenhouse system.
3. Do not open the _____ during heavy wind, rainfall and severe winter, else the greenhouse may get flooded.
4. All critical maintenance work related to faulty cables in the greenhouse should be done by the _____only.
5. The electric control panel should be protected from _____.

B. Multiple choice questions

1. What should be done to improve lighting conditions during cloudy days in a greenhouse?
   (a) Spread a silver net inside the greenhouse
   (b) Fold back the silver net inside the greenhouse
   (c) Cover the top with a shade net
   (d) None of these

2. The polyethylene film should be changed after every _____.
   (a) 1 year
   (b) 3 years
   (c) 2 years
   (d) 5 years
3. The entire greenhouse system should be shutoff in the evening or night except _____ system in severe winter.
   (a) Irrigation
   (b) Cooling
   (c) Heating
   (d) Fertigation
4. _____ is used to regulate solar radiation inside the greenhouse.
   (a) Insect net
   (b) Shade net
   (c) Mulching sheet
   (d) Weed mat

C. Subjective questions

1. List the measures to be taken for the maintenance of a greenhouse.

   _____
   _____
   _____

2. What steps should be taken to maintain an exhaust fan?

   _____
   _____
   _____

3. What precautions should be taken while running a heating system?

   _____
   _____
   _____

4. Why should polyethylene or cladding material be washed periodically? How should it be done? What are the precautions to be taken while washing?

   _____
   _____
   _____

D. Match the columns

A	B
1. Greenhouse	(a) Water
2. Footwear	(b) Two doors
3. Protect motor	(c) Kept outside

Session 2: Care and Maintenance of Drip Irrigation and Fogging Systems

Notes

There are four types of maintenance schedules of drip irrigation system.

1) Daily maintenance
2) Fortnightly maintenance
3) Periodic chemigation
4) Seasonal, storage and re-installation maintenance

General Maintenance Guidelines for Filters

Emitters, mini sprinklers and drip lines have to be safeguarded from clogging. Proper maintenance of filters is essential to avoid clogging. This results in maximum efficiency of the irrigation system.

Daily maintenance

- Start the pump and let the pressure stabilise in the system and check for leakages.
- Depending upon the irrigation design, correct the pressure at the sub-main level, by adjusting the throttle.
- Inspect whether water is reaching all the corners of the beds. If it is not, find the cause and correct it. If there is any twist, fold, cut, punches, or any such thing causing variation, correct it immediately.
- Inspect whether the uniform wetting pattern is seen at the end of the irrigation shift. If dry patches are found, check the drippers.
- Check for the formation of scale or solid substance precipitated from a solution and damages caused, if any.
- In case of any damage in the drip lines causing leakage, correct it by using proper joints.
- Flush all the drip lines by opening the end plugs, starting from the nearest point to the water source allowing flushing for three minutes or more till clean water starts flowing.
- Flush each of the sub-mains at the end of the irrigation until dirt-free water flows out. Check the pressure level at both the inlet and outlet of the filters by using a pressure gauge.

- Remove slurry from the hydrocyclone filter after every five hours.
- The screen or disc filter, hydrocyclone and media filter should be flushed every day. Back wash or flush out the filtration system before switching on/ off the irrigation system.

Periodic or fortnightly maintenance

- Take out the elements of the screen filter or disc filter and clean them properly.
- Clean the media filter by reversing the direction of the flow and stirring the media manually while the system is in operation.

Periodic chemical treatment

Quality of water is the most important factor for successful functioning of a drip system. The drip system consists of a large number of emitters, which have very small flow paths. The emitters are prone to blockage or clogging due to contamination in source water.

A drip system could be clogged due to the following reasons:

- The presence of large particles as well as suspended silt and clay load in source water
- Growth of bacterial slime in the system
- Growth of algae in the water source and in the drip system
- Bacterial precipitation of iron or sulphur
- Chemical precipitation of iron
- Chemical precipitation of dissolved salts (present in source water) in laterals, drip tapes and drippers.
- Mechanical disruption due to some breakage or broken components.

Physical treatment like filtration does not remove the dissolved solids or salts, bacteria or microscopic algae from water. Bacteria and algae can grow in the drip system or can interact with particles of silt and clay and form clusters or catalyse precipitation of salts. Such precipitation can cause clogging or blockage of

laterals and drippers. Chemical treatment of water either at source or within the system is the most useful method of preventing or rectifying the clogging problem. In chemical treatment, acid or chlorine is injected in the drip irrigation system with irrigation water. Water analysis is the most reliable way to decide on chemical treatment. Soil and water samples should be collected during the survey and then analysed to recommend acid or chlorine treatment as per the quality of water being used.

Seasonal, storage and re-installation maintenance

- Before retrieving the system, carry out fortnightly maintenance.
- Remove end plugs and wind drip lines from the end plug side to the starting connector in separate rolls for each row. Farmers often disconnect the drip lines from the sub-main and stack them there to carry out inter-cultural operations. This should not be done.

Maintenance of Hydrocyclone Filters

- A hydrocyclone filter does not require much care for its maintenance. However, the inside portion of the under flow chamber should be checked and accumulated dirt, if any, must be cleaned. The chamber must be flushed by opening the flush valve or cap or the main valve.
- Dirt has to be cleaned regularly. The walls can erode due to excess pressure and/or uncleaned dirt chamber.

Maintenance of Sand Media Filter

- Sand filter is effective for removing heavy organic and inorganic contaminants. In due course of time, the contaminants in water accumulate and clog the pore space of the filter, reducing its efficiency. A sand filter must be backwashed daily. Backwashing is a process that involves reversing the water flow. It results in lifting of the sand to release the collected dirt through a backwashing valve.

- Backwash flow must be adjusted properly because insufficient backwash flow will not clean the sand properly.

Maintenance of Screen Filter

- A screen filter should be flushed daily for proper maintenance. If the pressure falls to more than 0.5 kg/cm^2 (5 m at water head), then flushing of the screen filter is recommended. Checking the inlet and outlet pressure helps in observing the pressure difference.
- Flushing is done by opening the drain valve and allowing the force of water to flush out the dirt through the drain valve. It is also necessary to clean the screen at regular intervals. For cleaning screen filters, the lid has to be opened to remove the screen filter and then cleaned under flowing water, rubbing it gently with a soft cloth or nylon brush, etc.
- While cleaning, be careful to avoid scratches. If any portion gets scratched, it should be painted with oil paint to avoid corrosion.

General Maintenance Guidelines for Foggers

- Proper operation of foggers is important to maintain temperature and humidity in the greenhouse. Water quality is very important for proper operation of the foggers. If the water is hard and saline, it blocks the hole of the nozzle. The water pH should be less than 7.
- For chemical treatment of hard water, do not use acid in flowing water as it will damage the plants. Always take out nozzles periodically and simply keep them in a plastic bucket containing diluted acid for one night. The next day, wash all the nozzles with fresh water. Sometimes, if there is excessive salt deposit, air pressure could be needed to clean the same. After washing with fresh water, again fix it with anti-leak. Do not use any pin or nail or a sharp object, etc., to clean the fogger nozzle.
- Always check and clean the filters daily before operating the fogger system. While operating the

fogger system, check the pump pressure daily near the filter because sometimes due to clogging of the filter, the inside pressure gets reduced.

(a) Screen filter cleaning

(b) Disc filter cleaning

Fig.1.1: Cleaning of filters

Practical Exercise

Activity 1

Visit any farmer's field that has drip irrigation and note down the measures being carried out for filter maintenance.

Material required: Writing material

Procedure

- Visit the field with prior appointment and permission to clean filter.
- Observe the type of filter.
- Carry out maintenance based on the type of filter.

Activity 2

Draw different filters used in a greenhouse irrigation system and their sequence from water source to plant.

Material required: Writing material

Procedure

- Enlist the types of filters used.
- Write briefly about these filters.

Activity 3

Visit a farmer's greenhouse and ask him to open any filter and explain how it is cleaned.

Material required: Writing material

Procedure

- Open the filter.
- Clean the filter as suggested.
- Retighten the filter.
- Write down your observation.

Check Your Progress

A. Fill in the blanks

1. Physical and chemical treatment of water are the two important methods of rectifying _____.
2. The pH of water should be less than _____ for irrigation or fogging.
3. The role of water quality is very important in a _____.
4. The scratched portion should be painted with _____ to avoid corrosion.
5. Proper operation of foggers is important to maintain _____ and _____ in the greenhouse.

B. Multiple choice questions

1. A filter effective for removing sand particles from water is known as _____.
   (a) screen filter
   (b) sand filter
   (c) hydrocyclone filter
   (d) all of the above
2. When water contains algae, _____ is used for cleaning the water.
   (a) sand filter
   (b) chlorine
   (c) sulphuric acid
   (d) screen filter
3. It is recommended to flush the screen filter, if pressure falls to more than _____.
   (a) 0.5 kg/cm^2
   (b) 1.0 kg/cm^2
   (c) 1.5 kg/cm^2
   (d) 2.0 kg/cm^2
4. The clogging of a drip system could be due to _____.
   (a) growth of algae in the drip system
   (b) chemical precipitation of iron
   (c) bacterial precipitation of sulphur
   (d) all of the above

5. Generally, how many types of maintenance schedules are advised for drip irrigation system?
   (a) 2
   (b) 3
   (c) 4
   (d) 5

C. Subjective questions

1. Why should we use different filters in a greenhouse irrigation system?

   _____

   _____

   _____

2. What are the major causes of clogging in a drip system?

   _____

   _____

   _____

3. Explain the maintenance of a sand filter.

   _____

   _____

   _____

D. Match the columns

A	B
1. Physical method	(a) Drain valve
2. Chemical treatment	(b) Filtration
3. Flushing of dirt	(c) Chlorine treatment

SESSION 3: SANITATION PRACTICES IN GREENHOUSES

For maximum benefits, the environment in greenhouse cultivation should be healthy. The following practices, if adopted, would lead to better production inside the greenhouses.

- Keep the premises neat and clean.
- Use a sanitiser before entering the greenhouse or net house.
- Do not allow people other than regular workers inside the structure.

- Use double door entry (anteroom) but always open only one door at a time. It must be closed immediately after you enter, to avoid pest and disease infestation.
- Stick yellow sticky traps in the ante room or paste yellow polythene on the walls and spread grease on it to check the entry of small insects, etc.
- Always use safety shoes, apron, cap, goggles and gloves while working.
- Always keep a first-aid box handy. It should contain bandage, band-aid, potassium permanganate, cotton, iodine, pain reliever, etc.
- Always use a folding ladder, scaffolding, scissors or lift while working at a height. Don't use a single ladder while working at a height.
- Keep a fire hydrant equipped with CO_2 cylinder so that it can be used immediately in case of fire.
- Display the contact number of ambulance, hospitals, police station, fire station and emergency at the site.
- Do not smoke and chew tobacco at the site while working.
- Keep chemicals in a proper plastic packing jar.
- Always wash your hands with a sanitiser before having lunch or dinner.
- Use a rubber mat while working with an electrical equipment.
- Always switch off the mains while working with any electrical equipment.
- Do not burn any plastic items while working. Keep them at one place for safe disposal.
- Use protective clothes while working. Try to wear cotton clothes.
- Do not throw or burn any plastic carry bag, empty packet, bag and boxes at the site. Keep them safely at one place, away from the reach of children or animals (animals should also be kept away from the greenhouse area).
- Do a mock drill operation for emergency once in a fortnight or monthly so that workers remain aware about the safety measures during an emergency.

- Always conduct periodic training related to sanitation, safety and health.

Practical Exercise

Activity 1

Visit a farmer's field that has a polyhouse and note down the observations on different aspects of sanitation.

Material required: Writing material

Procedure

- Visit the field that has a polyhouse.
- Note down the sanitary practices that are followed by the farmer by observing as well as interacting with the farmer.

Check Your Progress

A. Fill in the blanks

1. _____ cylinder should be kept near the fire hydrant so that it can be readily used in case of fire.
2. Use _____ mat while working with an electrical equipment.

B. Multiple choice questions

1. Which contact numbers should be displayed at a working site?
   (a) Ambulance
   (b) Hospital
   (c) Police station
   (d) All of the above
2. The greenhouse should have a _____.
   (a) single door
   (b) double door
   (c) both (a) and (b)
   (d) none of the above.
3. While working at height, always use a _____.
   (a) single ladder
   (b) folding ladder
   (c) both
   (d) none of the above

C. Match the columns

A	B
1. Anteroom	(a) Fire hydrant
2. CO_2 cylinder	(b) Iodine
3. First-aid box	(c) Working with electrical equipment
4. Rubber mat	(d) Double door entry

D. Subjective questions

1. Explain the sanitary requirements in and around a greenhouse.

   _____

   _____

   _____

2. Explain the importance of a clean greenhouse cultivation.

   _____

   _____

   _____

Unit 2

Protected Cultivation of Rose, Gerbera, Carnation, Lilium and Orchids

Open field flower cultivation is mostly dependent on natural climatic conditions, where the crops are often damaged due to high winds, untimely as well as excess rainfall, flood, high or low temperature, less or more humidity, pests, diseases and soil-borne problems, etc. To manage these challenges, protected cultivation techniques are gaining momentum. Under protected cultivation technologies, the crop canopy is covered with different materials (insect-proof net, shade net, polyethylene film, etc.). Under protected conditions, the crops are grown inside different protected structures such as a greenhouse having controlled condition parameters like light, temperature, humidity, irrigation, soil, which are managed and maintained with the help of different control systems. With the rise in demand for quality cut flowers, cultivation under greenhouse conditions will increase steadily. The common flowers cultivated under polyhouse conditions are — roses, gerbera, carnation, lilium, anthurium, orchids, etc.

Session 1: Protected Cultivation and Package of Practices for Roses

Rose is popularly known as the queen of flowers. It is a leading cut flower, grown commercially all over the world. Rose stands first in the global cut flower trade. Rose is cultivated for cut flower, oil-extraction, rose water, and flavouring agents. Some rose species are rich in Vitamin C. Rose petals are used for preparing *gulkand* and *pankhuri*. Earlier, commercial rose cultivation in India was mainly in open-field conditions. Later, improved cultivation practices like mulching, drip irrigation, fertigation, better canopy management practices, and use of improved varieties or hybrids boosted the rose cultivation. With the introduction of greenhouse technology in India during the late 1990s, export quality cut rose cultivation began in entrepreneurial mode.

Classification

Roses can be classified mainly into the following types.

- Hybrid tea: They are most popular in modern days and bear large flowers.
- Floribunda: They are also known as hybrid polyanthas.
- Polyanthas: They produce enormous clusters of small flowers, which bloom for several months.
- Climbers and ramblers: Climbers grow upward with the help of modified organs. Ramblers are climbers with large clusters of small, single or double flowers.
- Miniatures: They are popular baby roses with small leaves and flowers. They are hardy and ideal for growing in pots.
- China roses: They are the ancestors of the present day popular roses. They show variation in colour from deep red and maroon to pink or white. They are bushy and often with an irregular outline.

(a) Hybrid tea rose

(b) Floribunda rose

(c) Polyanthas

(d) Climbers and ramblers

(e) Miniature roses

(f) China rose

Fig. 2.1: Classification of different roses

Table 2.1: Varieties used for cut flower purpose

Flower colour	Varieties
Red	Jaguar, Gabriella, Sasha, Grand Gala, First Red, Dallas, E.G. Hill, Happiness, Taj Mahal
Pink	Kiss, Europe, Prophyta, Royal, Nobles, Pink, Aristocrat, Better Times
Bi-colour	Amour, Rodeo, Confetti, Ambience, Leonidas, Yellow Gloria
Orange	Indian Puma, Candid, Mercedes, Jazz, Orange Delight, President Herbert
Yellow	Golden Time, Golden Gate, Frisco, Golden Rapture, Golden Sceptor
Cream	Prestige, Vivaldi, Versilia, Florence
Purple	Jacaranda, Souvenir
White	Eskimo, Double White Killarney, White Pearl

Temperature and Humidity

Rose requires good light throughout the year. Temperature range of 15°C to 28°C and relative humidity around 75 per cent is ideal for quality rose cultivation.

Soil

Soil should be well prepared to a good depth and well-drained, rich in organic matter with a pH range of 5.5 to 6.5. For cultivation of rose, sandy loam soils are preferable.

Propagation

- Cuttings: Fresh and mature shoots should be selected for propagation by the cutting method. The cut ends of the shoots should be dipped in Indole Butyric Acid (IBA) (rooting hormone) and planted in beds. This method is practised only for multiplication of rootstock and a few classes of rose, for example, miniatures and climbers.

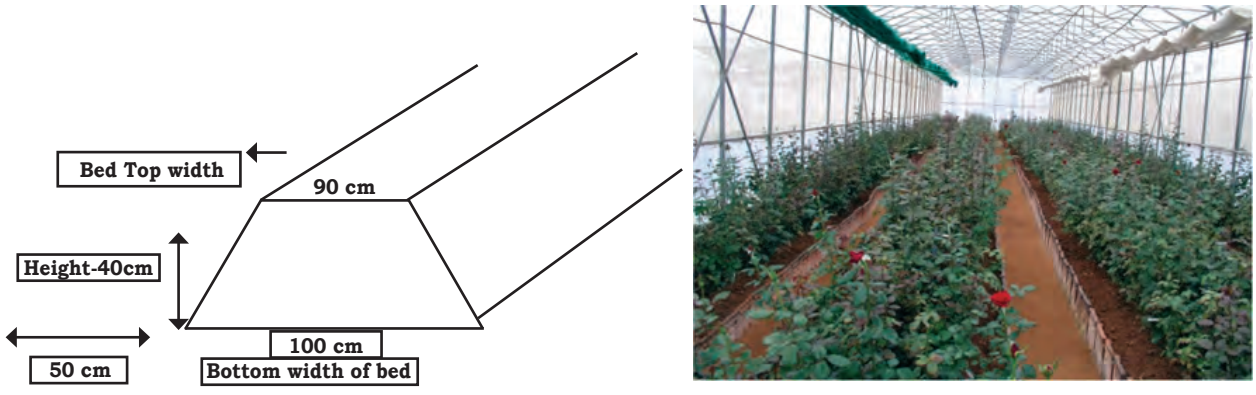
- Budding: This is the most common method of propagation, although tedious and time consuming. Budding is done in February–March, when dormant eyes on a scion of chosen variety are budded either by the T-budding method or inverted 'T' method on a native rootstock.

Fig. 2.2: Budding in rose

Bed Preparation

Cut rose cultivation should be done on raised beds. Soil should be prepared thoroughly and mixed well with organic matter at 50 t/ha FYM. FYM should also be preferably enriched with bio-agents like *Trichoderma harzianum* and/or *Pseudomonas fluorescens,* which are mixed well separately in different heaps of FYM and kept for about a month. They should be mixed just before applying FYM in the planting beds. A little sand and rice husk may be added to the soil for better drainage and non-compaction. The soil should be fumigated if possible or soil solarisation should be done thoroughly before bed preparation. Then the raised beds of the following dimensions should be prepared.

- Bottom width — 100 cm
- Top width — 90 cm
- Path width — 50 cm
- Height — 40 cm



(a) (b)

Fig. 2.3 (a and b): Bed preparation

Planting

Planting is done on the bed with paired row system in a zigzag fashion. Plant to plant distance should be maintained at 20cm and row to row spacing at 40 cm. While planting, care should be taken that the budded portion is above the ground level. About 48,000 plants can be accommodated in a one acre greenhouse.

Common Cultural Operations Involved in Rose Cultivation Under Greenhouse Conditions

Pruning

It should be done between October and November. At the time of harvesting, a cut is given on the second pair of leaves in the first year plant. In subsequent years, pruning is done on the wood that has grown after the previous pruning.

(a) (b) (c)

Fig. 2.4 (a, b and c): Pruning in rose

Pinching

In this process, a part of the terminal growing portion of the stem is removed to promote auxiliary branching and delay maturity of the buds.

Stem bending

In this process, the stems are bent in such a manner that the angle between the original and the bent shoot is less than 45°. This is generally carried out five months after planting for breaking the apical dominance of the plant. This helps in breaking apical dominance and simultaneously provides active foliage for photosynthesis resulting in the development of reproductive flower stems.

Fig. 2.5: Stem bending in rose

Fig. 2.6: Rose plant after bending

Manures and Fertilisers

Rose plants require 200–300 kg of nitrogen, 150–200 kg/ha each of phosphorous and 200–300 kg/ha potassium depending upon the fertility status of the soil. Nitrogen is applied in split doses. The first dose is applied at the time of pruning and the second dose 25–30 days after pruning. The basal dose of fertilisers may also be supplemented with foliar feeding, consisting two parts urea, one part di-hydrogen ammonium phosphate, one part potassium phosphate and one part potassium nitrate, and using 3 g of this mixture/L of water after one week or 10 days till flowering.

Fertigation with drip irrigation is given in roses at the rate of 80–100 ppm of N, 50–60 ppm of P and 60–80 ppm of K two to three times per week, while micronutrients at the rate of 25–50 ppm once in two weeks or weekly. The following fertigation schedule should be followed, preferably.

Table 2.2: Month-wise fertigation schedule for rose under protected cultivation (1000m²)

Particulars	Month-wise application of water soluble fertilisers (kg/1000m²)												
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Irrigation nos.	4	6	7	8	8	8	6	6	8	8	6	4	79
Urea phosphate	1.5	2.1	3.7	4.5	5.1	5.3	3.4	2.9	2.9	2.9	2.7	1.7	38.7
Urea	1.9	2.6	4.5	5.2	6.0	6.2	4.0	3.3	3.4	3.4	3.2	2.1	45.8
SOP	1.8	2.5	4.3	6.4	7.2	7.5	4.8	4.1	3.1	3.1	3.1	2.0	49.9

Source: Hasan et al. 2010. *Fertigation Scheduling for Horticultural Crops*. Technical Bulletin. TB-ICN: 80/2010, p. 44, I.A.R.I., New Delhi.

Common Pests and Diseases

The key pests and diseases in rose plants are mites, aphids, thrips, leaf miner, die-back, black spot, powdery mildew, collar rot, root rot, etc. The management of pests and diseases has been discussed in Unit 4, Session 2.

Harvesting

- **For local market**: When the outer one or two petals start unfurling.
- **For distant market**: A tight bud showing complete colour stage should be harvested.
- **Loose flower**: Fully opened flowers.
- The red flowers may not open if harvested at the tight bud stage but white, pink and yellow cultivars are harvested earlier than red.

Post-harvest Management

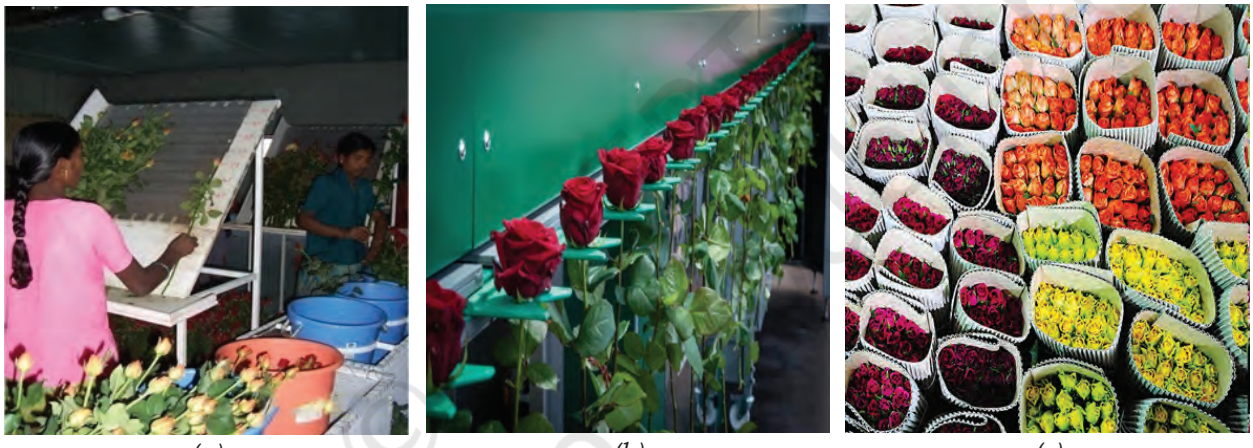
After harvesting, the flower stems should be kept in buckets containing water in a vertical position for a few hours, to remove the field heat and retain the moisture and then shifted to cold rooms (3–5°C) for

better shelf life. During cooling, the stems should be put in aluminium sulphate or citric acid (300 ppm) or bleach solution (50 ppm chlorine for disinfestations).

Grading and Packaging

Stems should be graded in an air conditioned room after pre-cooling. Healthy stems should be sorted out as per the grade depending upon the stem length, cultivar and quality of the flower. The bud size should be representative of the variety and the length of the neck should not be much. Grading can be classified into:

Long stemmed (70–120 cm): with 10 cm difference,
Medium stemmed (50–70 cm): with 5 cm difference, and
Small stemmed (30–50 cm): with 3–5 cm difference.



(a) (b) (c)

Fig. 2.7 (a, b and c): Grading and packaging

The graded stems are sorted into bundles of 20 each, tied loosely with a rubber band and wrapped with a 2-ply soft corrugated paper. The bunches are packed in pre-cooled 5-ply tele boxes of fibre board in such a way that the flower heads face the opposite direction.

Yield

A yield of 150–250 quality flower stems per m^2 per year can be expected under protected conditions for six to eight years.

Practical Exercise

Activity 1

Visit a greenhouse rose field and observe different horticultural operations practiced in the greenhouse cultivation of rose.

Material required: Writing material

Procedure

- Visit a field and note down the varieties.
- Note down the observations on common cultural operations carried out by the farmers.
- Note down the importance of each operation.

Check Your Progress

A. Fill in the blanks

1. Most preferable soil for the cultivation of rose is_____.
2. Pruning of roses should be done in the month of _____.
3. The ideal relative humidity for quality rose cultivation is _____ per cent.
4. The optimum temperature for growing of roses is _____.
5. Commercially roses are propagated by _____ method.

B. Multiple choice questions

1. Which one of the following is not a type of rose?
   (a) Floribunda
   (b) Designer
   (c) Miniature
   (d) Rambler
2. Which of the following activities is not done in rose production?
   (a) Pinching
   (b) Stem bending
   (c) Pruning
   (d) Pulsing
3. How many plants can be accommodated in a one acre greenhouse?
   (a) 30,000–35,000
   (b) 35,000–38,000
   (c) 40,0000–42,000
   (d) 45,000–48,000

4. Rose petals are used to prepare _____.
   (a) *gulkand*
   (b) *pankhuri*
   (c) both (a) and (b)
   (d) none
5. The ideal pH range for rose cultivation is _____.
   (a) 4.5–5.5
   (b) 5.5–6.5
   (c) 6.5–7.5
   (d) 7.5–8.5

C. Subjective questions

1. Write the names of three varieties of bi-colour rose.

   _____

   _____

   _____

2. Explain the two major diseases of rose.

   _____

   _____

   _____

3. What is stem bending?

   _____

   _____

   _____

4. List out common pests and diseases of rose.

   _____

   _____

   _____

D. Match the columns

A	B
1. Thrips	(a) Rose variety
2. Tight bud	(b) Disease of rose
3. First red	(c) Pests of rose
4. Black spot	(d) Harvesting stage

NOTES

Session 2: Protected Cultivation and Package of Practices for Gerbera

Gerbera flower is a native of South Africa and currently one of the most favoured and liked cut flowers across the world, and is very popular among greenhouse growers. Its beauty, variety of colours, and shape is most likeable for different purposes, be it some occasion or decoration, bouquet preparation or beautification. It is available both in single and double florets with black centred varieties being in high demand in national and international markets. Commercially, the single and semi-double types of gerbera are grown mainly for garden decoration whereas the double type varieties are grown for cut flower trade.

(a) (b)

Fig. 2.8 (a and b): Gerbera cultivation in a polyhouse

Climatic Requirement

Day temperature range between 22–25°C and night temperature range between 12–16°C is favourable for a good crop of gerbera. Poor light during winter adversely affects the flower production, hence, measures such as opening of silver shade net during the day should be taken.

Soil

Light sandy loams, slightly acidic or neutral soils are good for gerbera cultivation. A good amount of organic matter along with rice husk provides good aeration and growth of the plants. Gerbera is a long duration crop of four to five years, therefore, healthy soil management

is very crucial to the crop. Even slight degradation in the health of soil and pathogenic infestation can lead to early mortality of the crop. Besides, it is generally grown on raised beds, which cannot be disturbed during crop life. Therefore, the soil has to be properly treated, thoroughly prepared, and well-mixed with farmyard manure and rice husk for efficient drainage. Farmyard manure mixed in the bed must be enriched with beneficial microbes like *Trichoderma harzianum*, *T. viride* or *T. virens* and *Pseudomonas fluorescens*.

Varieties

A large number of commercially important varieties are grown in different parts of the world. Among them, Anneke, Alsmeera, Alexias Ginna, Ibiza, Lyonella, Monique, Ornella, Parade, Gold Spot, Regina, Sunset, Tara, Rosetta, Gloria, etc., are grown in India under protected cultivation for local and export purpose.

Fig. 2.9: Different colour varieties of gerbera

Fig. 2.10: Tissue-cultured planting material of gerbera

Propagation

Gerbera may be propagated through seeds, tissue culture or through division of clumps. However, the propagation of gerbera through division and tissue culture is the norm. It is advisable to buy plant materials from recognised commercial suppliers only, as the yield and quality depends on the quality of planting material.

Time of Planting

Planting is generally done during January–March and also during June–August. It is important that they are not planted too deeply, that is, the crown of the plants should be at soil level or a little above it.

Fig. 2.11: Prepared beds of gerbera

Planting and Spacing

Gerberas are mainly planted on a raised bed of 1 m width and 50 cm height with a 30 cm passage between the beds. Row to row distance is to be 30 cm and plant to plant distance has to be 20 cm. By following this spacing, it is possible to accommodate about 60,000 plants per acre inside a greenhouse.

Fig. 2.12: Transplanting of gerbera under a raised bed

Fig. 2.13: Transplanted field of gerbera

Nutrient Management

Gerbera is a heavy feeder. It requires an application of 10:15:20 g NPK/m^2/month during the first three months

of planting, starting from the third week and 15:10:30 g NPK/m^2/month from the fourth month (when flowering starts). Spraying of micronutrients like boron, calcium, magnesium, and copper @ 0.15 per cent (1.5 ml/L) once in a month is also recommended to get better quality bloom. Now, for commercial purposes, nutrition is given through fertigation. Mixed micronutrient formulations (25–50 ppm) may also be given fortnightly. The following fertigation schedule is to be adopted for gerbera cultivation in greenhouses.

Table 2.3: Month-wise fertigation schedule for gerbera under protected cultivation (1000m^2)

Particulars	Month-wise application of water soluble fertilisers (kg/1000m^2)												
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Irrigation nos.	4	6	7	8	8	8	8	8	8	8	6	4	79
Urea phosphate	1.5	2.1	3.2	4.6	2.1	2.1	1.4	1.4	2.5	2.6	2.7	1.7	27.6
Urea	1.4	1.9	2.9	4.2	2.5	2.6	1.7	1.5	2.4	2.5	2.4	1.5	27.5
SOP	1.8	2.5	3.7	5.4	3.0	3.1	2.0	1.7	2.6	2.7	3.1	2.0	33.8

Source: Hasan et al. 2010. *Fertigation Scheduling for Horticultural Crops*. Technical Bulletin. TB-ICN: 80/2010, p. 44, I.A.R.I., New Delhi.

Irrigation and Water Management

After planting, initially up to four weeks, the crop should be irrigated with water cans, and later drip irrigation should be used. The crop has a water requirement of 2–4 L/m^2/day.

Fig. 2.14: Drip irrigation

Weed Management

Uproot the weeds if any, when they are small. Two to three manual weedings may be required. The first weeding should be done one month after planting.

Harvesting

Gerbera starts flowering 8–12 weeks after planting. Harvest the fully opened flowers two to three times in a week. The stems should be pulled, not cut and the 'heel' (base of the stem) should then be cut by secateurs to allow hydration. Freshly harvested cut gerbera stems can last from seven to 10 days depending upon the varieties. Gerbera flowers are preferred only when the diameter of the flower is more than 12 cm. Therefore, grading is done based on the size, colour, and stalk length of the flowers.

Post-harvest Management of Gerbera

Gerbera stem is highly prone to bending. A bent stem is not accepted well in the trade. The stem should not be less than 40 cm and should be firm and straight. The flower should be uniform in size and should not be less than 7 cm in diameter. Gerbera flowers are packed in flat boxes containing paper inserted with holes for individual stems. Support is necessary to hold the stems immobile. For domestic purpose, individual flowers can be inserted in polyethylene sleeves before packing, to protect them from damage caused by bruising.

(a) (b) (c)

Fig. 2.15 (a, b and c): Packaging of gerbera

Yield

The average yield in a greenhouse is around 200 cut flowers/m^2 per year, of which, around 85 per cent is of first grade quality.

Success Story of a Gerbera Grower

Smt. Mamata Varshney, M.A. from village Tarasevaniya in Bhopal district, underwent a training programme on protected cultivation technologies in 2015 at Precision Farming Development Centre (PFDC). After availing a subsidy from the State Horticulture Mission, she established a Naturally Ventilated Polyhouse of 2000 sq.m and started cultivating gerbera.

Courtesy: CIAE, Bhopal
Figure: A successful gerbera grower in Bhopal

PFDC staff provided her technical guidance for the layout of the polyhouse as well as in crop management from time to time. She invested ₹ 10 lakh for the installation of the polyhouse. She has employed two agricultural labourers. By adopting this technology, she not only produced quality flowers but also got a high market price. At present, her annual income from gerbera cultivation in a polyhouse is about ₹ 6 lakh. Having found the techno-economic advantage of polyhouse cultivation, she is planning to extend the polyhouse area by one more acre.

Practical Exercise

Activity 1

Visit a nearby gerbera growing field and observe different cultural operations practised in greenhouse cultivation.

Material required: Writing material

Procedure

- Note down the observations on common cultural operations carried out by farmers such as the number of plants per sq. m, name of variety, colour of flower, plant spacing, etc.
- Note down the method of harvesting of flowers.
- Note down the expected yield per m^2.

Check Your Progress

A. Fill in the blanks

1. The average yield of gerbera in a greenhouse is around _____ per m^2 per year.
2. In one acre greenhouse, we can accommodate about _____ plants of gerbera.
3. The water requirement of gerbera is _____ litre per day per m^2.
4. Gerbera is a native of _____.
5. Day temperature range between _____ and night temperature range between _____ is favourable for a good crop of gerbera.

B. Multiple choice questions

1. Gerbera starts flowering _____ weeks after planting.
   (a) 2–3
   (b) 4–6
   (c) 8–12
   (d) 15–20
2. The average gerbera flower yield in a greenhouse is around _____.
   (a) 50 flowers/m^2/year
   (b) 100 flowers/m^2/year
   (c) 200 flowers/m^2/year
   (d) 400 flowers/m^2/year
3. Which of the following is/are gerbera variety(ies)?
   (a) Anneke
   (b) Alsmeera
   (c) Alexias Ginna
   (d) All of the above

4. Farmyard manure mixed in the bed must be enriched with beneficial microbes such as _____.
   (a) *Trichoderma harzianum*
   (b) *T. viride*
   (c) *Pseudomonas fluorescens*
   (d) All of the above

C. Subjective questions

1. Write about the bed preparation and method of planting of gerbera.

   _____

   _____

   _____

2. Write a short note on grading and packing of gerbera flowers.

   _____

   _____

   _____

3. Describe the nutrient management in gerbera.

   _____

   _____

   _____

D. Match the columns

	A	B
1.	Propagation	(a) Packing
2.	Polyethylene sleeve	(b) Micronutrient
3.	Boron	(c) Division
4.	Bent neck	(d) Disorder

SESSION 3: PROTECTED CULTIVATION AND PACKAGE OF PRACTICES FOR CARNATION

Carnation (*Dianthus caryophyllus* L.) is one of the most popular commercial cut flowers of the world, ranking second in commercial importance after rose. Several exporting countries prefer carnations over roses and chrysanthemums because of its excellent keeping

quality, wide range of forms and colours and its ability to withstand long distance transportation. Cut carnations, roses and chrysanthemums contribute close to 50 per cent of the world's cut flower trade.

Fig. 2.16: Carnation crop

Climatic Requirement

Carnation is one of the most delicate crops and hence requires a very congenial environment, which is stress free and ideal for proper and healthy growth of the plants. The general environmental requirements of the crop are as follows:

- Light: Carnation is a quantitative long day crop (long days of more than 13 hours), so it prefers plenty of sunshine. 100 watt bulbs spaced at 10.5 m and of 1.5 m height can be installed above the foggers if the light intensity is less.
- Day Temperature— 15°C to 18.3°C (up to 25°C) and night temperature— 10°C–15°C.
- Ventilation: Free circulation of air in a naturally ventilated greenhouse or else forced ventilation with gentle flow of air is favourable.
- Relative humidity: 50–60 per cent
- CO_2: 500–1500 ppm

Soil

- Light textured loamy soil or sandy loam soil is ideal for its cultivation.
- Soil pH: 6–7

- Soil has to be treated properly, thoroughly prepared, and should be crisp, well-mixed with properly decomposed farmyard manure and rice husk for efficient drainage. Farmyard manure mixed in the bed must be cured and enriched with beneficial microbes like *Trichoderma harzianum, T. viride* or *T. virens* and *Pseudomonas fluorescens.*

Varieties

Popular cultivars of carnation are Dona, Pink Dona, Dakar, Disney, Dark Tempo, Empire, Eilat, Elvis, Fancy Fuego, Liberty, Malaga, White Dona, Rony, Rhodos, Lipstick, Mila, Milky Way, Romana, White Tendra, Corleone, Design, Natila, Bagatel, Silvery Pink, Solar, Cobra, Pendy, Lorella, Cabaret, Tanga, Sonsara, Green Lady, Tempo, Varna, Charment, Red Eye, Red Fuego, Red Vital, Aveiro, White Prestige, T-587, Rosa Bebe, Spur, Suprema, D-925, Celebration, Osiris, Stella, Prestige, Sonia, Abril, Autumn, Sunshine, Berry, Orbit Plus, Nadeja, Picaro, etc.

Propagation

Rooted terminal stem cuttings

- Carnation is commercially propagated through stem cuttings. Terminal stem cuttings from well maintained mother plants, measuring 10–15 cm and 7–10 cm long with four to five leaves are selected for multiplication.
- These cuttings are treated with carbendazim (0.1 per cent) for reducing the spread of fungal diseases during rooting. The lower ends of cuttings are treated with NAA 500 ppm for five seconds to encourage rooting. Carnation cuttings can also be rooted in a mist chamber for better success. Treated cuttings are planted in sand/vermiculite/perlite/cocopeat, etc., media for propagation. Carnation cuttings start rooting within a month after planting in a mist chamber. After complete rooting, the cuttings are transferred into a hardening chamber containing sterilised mixture of sand:soil:FYM (1:1:1).

Fig. 2.17: Terminal cuttings of carnation

Fig. 2.18: Bed preparation for carnation

Fig. 2.19: Sterilisation of the bed by formaldehyde

Fig. 2.20: Bed preparation

Micro-propagation (Tissue culture)

Large scale multiplication of disease free carnation plantlets is done through tissue culture method.

Bed Preparation

Raised beds should be prepared with application of 5 kg coir pith with 15 g N, 20 g P_2O_5 and 10 g K_2O, per square meter area. Planting in carnation is done on raised beds of 25–30 cm height, 1 m width and of convenient length. Before planting, chemical soil sterilisation with 4 per cent formaldehyde (160 ml of formaldehyde in four litres of water) is the norm. After formalin application, the beds should be covered with plastic sheets for 2–3 days. Irrigate the beds after removing these sheets, in such a way that all the chemicals drain out from the beds before planting. However, formaldehyde is being phased out and hence should be avoided. Hydrogen peroxide (silver nano formulations) can also be used for bed treatment.

Time of Planting

- North Indian plains: September–October
- Low hills: September–November
- Mid hills: January–February
- High hills: March–April

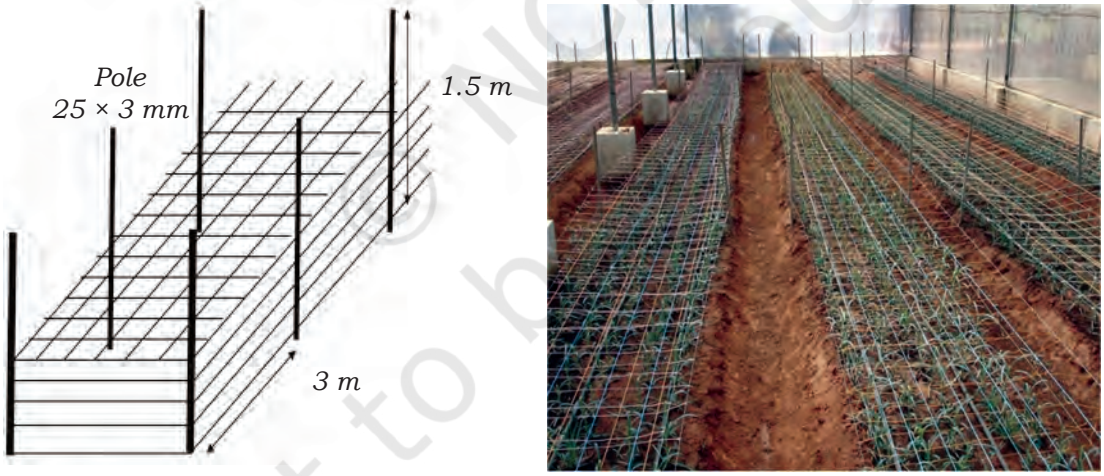
Fig. 2.21: Prepared bed

Planting Method, Density and Spacing

Rooted cuttings plugged in soil or cocopeat should be planted at a distance of 15 cm between rows and 15 cm between plants, keeping one-third portion in soil and two-third portion outside for good establishment. The soil should be pressed with the thumb, placing the plug in the depression before covering it with soil from the sides and pressing gently. Usually, 32 plants/m^2 net area (per m^2 of bed) and about 20 plants per gross m^2 (per m^2 of greenhouse) are planted.

Support System (netting)

As carnation is vulnerable to bending, it should be supported with four to five successive layers of criss-cross support net of variable size of mesh, further supported well on the sides with GI pipe and GI wire lines to take the maximum weight. The supporting net should be 7.5 × 7.5 cm mesh. Four to five such layers of mesh should be tied as the plants gain in height. Also the mesh size of the net may be increased to 12–15 cm at the top.



(a) (b)

Fig. 2.22 (a and b): Support system (netting)

Pinching

Pinching should be done based on market demand. Pinching methods are single, one and a half or double pinch. Pinching can be done when the plants attain the six-node stage. The pinch is given three to four weeks

after planting. This is called single pinching. This gives rise to four to six lateral shoots. Two to three of these lateral shoots are pinched again for a 'one and half pinch'. For the 'double pinch', all the lateral shoots are pinched off.

Fig. 2.23: Pinching in carnation

Nutrient Management

- Standards— FYM: 5 kg, N: 30g, P: 20g, K: 10g/m^2
- Spray— FYM: 5 kg, N: 40g, P: 20g, K: 10g/m^2

Table 2.4: Month-wise fertigation schedule for carnation under protected cultivation (1000m^2)

Particulars	Month wise application of water soluble fertilisers (kg/1000m^2)												
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Irrigation nos.	4	6	8	6	8	8	6	6	6	8	6	4	76
Urea phosphate	1.0	1.4	2.1	1.5	1.7	1.8	1.1	1.0	1.5	1.8	1.8	1.1	17.9
Urea	1.1	1.5	2.3	2.4	2.6	2.7	1.8	1.5	1.8	2.2	1.9	1.2	23.0
SOP	1.3	1.8	2.8	2.7	3.0	3.1	2.0	1.7	1.8	2.1	2.3	1.5	26.3

Source: Hasan et al. 2010. *Fertigation Scheduling for Horticultural Crops*. Technical Bulletin. TB-ICN: 80/2010, p. 44, I.A.R.I., New Delhi.

These days nutrition is commercially given through fertigation. Mixed micronutrient formulations (25–50 ppm) may also be given fortnightly.

Irrigation and Water Management

- Lateral pipes for drip irrigation are laid over the planting beds at about 30 cm distance each. Thus, if there are five rows of plants on one bed width, three drip lateral lines may be laid.
- Normally, 2–3 litres of water/m^2/day is required for the planting bed, depending upon the agro-climatic conditions and location of the greenhouse.
- During the vegetative phase, overhead irrigation is beneficial.

Weed Management

- Since the plants are very delicate, the presence of weeds further weakens the stems leading to more bending, therefore, three to four hand weedings are done carefully.
- Chemical weedicides for annual grasses and broad-leaved weeds *viz.*, oxadiazon (pre-emergent) @ 500 g a.i./acre and napropamide (post-emergent) @ 1 kg a.i./acre can be used in a greenhouse.

a.i. — active ingredient

Harvesting

- Harvesting of the standard carnation flower should be done when the petals have started to elongate outside the calyx (paint brush or cross bud stage). The spray varieties are harvested with two open flowers on each stem. It takes 12–15 weeks for the single pinched plant to yield cut blooms. The best time for harvesting is in the morning. Flowers are harvested with a sharp knife or pruning secateurs leaving 2–3 leaves above the ground level. Immediately after harvesting, the flowers are placed in a bucket containing clean water or with 1 ml of sodium hypochlorite solution (15 per cent a.i.) in 10 litres of water.
- The common grades are: (A) over 45 cm, (B) 30–45 cm and (C) Less than 30 cm.

Fig. 2.24: Disbudding in carnation

Packaging

- In bundles of 10, 12, 20 or 25.
- One can accommodate about 800–1000 cut carnation flowers in corrugated cardboard boxes of 120 × 60 × 30 cm (L × W × H) each.
- Wrap flower bunches in CFB sleeves.

(a) (b) (c)

Fig. 2.25: Packaging of carnation

Yield

The expected yield is about 10–12 stems per plant per year (300 flowers/m^2).

Practical Exercise

Activity 1

Visit a greenhouse that grows carnation flowers and draw how carnations are supported.

Material required: Writing material

Procedure

- Note down the observations on common horticultural operations carried out by farmers for carnation cultivation viz., supporting, pinching, disbudding, nutrition, etc.
- Note down how they harvest and pack the flower stems.

Check Your Progress

A. Fill in the blanks

1. The most suitable soil for carnation cultivation is _____.
2. Carnation harvesting starts within _____ to _____ days after planting.
3. The commonly used propagation materials in carnation are _____ stem cuttings.

B. Multiple choice questions

1. The optimum CO_2 for carnation in greenhouses is _____.
   (a) 200–300 ppm
   (b) 300–500 ppm
   (c) 500–1500 ppm
   (d) 3000–3500 ppm
2. The optimum soil/media pH for carnation is _____.
   (a) 3–5
   (b) 5–6
   (c) 6–7
   (d) 8–9
3. Corrugated cardboard boxes of 120 × 60 × 30 cm (L × W × H), each can accommodate about _____ cut flowers carnation.
   (a) 100–200
   (b) 200–300
   (c) 300–500
   (d) 800–1000

C. Subjective questions

1. Explain the method of planting in carnation.

   _____

   _____

   _____

2. What should be the greenhouse climate for growing carnation?

   _____

   _____

   _____

3. Explain how carnations are supported.

   _____

   _____

   _____

D. Match the columns

A	B
1. Paint brush	(a) Support system
2. Netting	(b) Packaging
3. CFB sleeves	(c) Tissue culture
4. Micro-propagation	(d) Harvesting stage

Session 4: Protected Cultivation and Package of Practices for Orchids

Orchidaceae is a large family comprising 800 genera and 2,500 spp. of monocotyledons in the world. Orchids are the most accepted and fascinating flowers in the world. They are a high value commodity, sold at premium prices both in the international and domestic markets. Apart from this, they are also in high demand as potted plants. The orchid culture has become a highly developed and remunerative business venture all over the world.

Importance and Uses

Miniature orchids are grown in pots, baskets, etc., as potted plants for indoor gardening. Large flower producing types are commercially grown under protected structures (polyhouses/shade net houses) for cut flower production. Such flowers have good shelf life and have a higher value as cut flowers. Apart from their use as ornamentals, some of them are found to be edible and some others have medicinal value also.

Fig. 2.26: Orchid plants

Environment for Orchids

Temperature, light, humidity, aeration, CO_2 concentration, etc., are important environmental factors, which regulate the growth and flowering of orchids. Hence, they are commercially grown under protected structures.

Temperature

The optimum temperature required for most of the orchids is between 15°C and 26°C. Orchids can be grouped into three categories based on temperature requirements.

Warm orchids

These orchids require day temperature between 21°C and 29°C and night temperature between 18°C and 21°C for better growth and flowering.

For example, *Arachnis*, *Dendrobium*, *Vanda*, *Phalaenopsis*, *Aranda*, *Mokara,* etc.

Cool orchids

An optimum temperature between 15°C to 21°C during the day and between 10°C to12°C at night is suitable for cool orchids like *Cymbidium*, *Paphiopedilum*, *Calanthe*, *Miltonia*, *Pleione* and *Odontoglossum* for proper growth and flowering.

Intermediate orchids

Orchids like *Cattleya*, *Laelia*, *Oncidium*, Brassavola, and some species of *Dendrobium*, *Coelogyne*, etc., belong to this group. The temperature requirement is between 18°C to 21°C during the day and 15°C to 18°C during the night.

Light

The optimum light intensity for most orchids is generally between 3000–6000 foot candles. However, orchids like *Cypripedium* and *Phalenopsis* need light intensity of about 200–300 foot candles, and hence should be kept in comparatively shaded portions of the orchid house, while *Cymbidium* grows under a full sun. Therefore, depending on the type of orchids and climatic conditions of the region, one has to use a specific type of shade net for proper growth and flowering. Generally 50–75 per cent shade net is used.

Humidity

Humidity is very important for the good growth of the plants. Orchids prefer high humidity, about 70 per cent during the day. However, the requirement

varies according to the genera. Under high temperature conditions, humidity is required. The requirement is high for young plants also. The humidity inside the orchidarium can be maintained by mist irrigation or by fitting humidifiers. Excessive high relative humidity (above 70 per cent) contributes to the succulent growth of the plants, and takes care of diseases.

Aeration

A majority of orchids are epiphytic, for which free air circulation is essential. Air impurities like dust particles and gases like ethylene can damage the flowers. Most of the commonly grown orchids have aerial roots, hence fresh moving air around the roots improves the plant growth and the quality of flowers. The circulation of fresh air is also essential to maintain the uniformity of temperature. It also reduces the occurrence of diseases and physiological disorders.

Propagation

Orchids can be propagated both by sexual (seed) and asexual (vegetative) methods. Seed propagation is mainly practised for breeding purposes. Different vegetative propagation methods usually practised include division, cutting, back bulbs, off-shoots and tissue culture. Tissue culture is the most common method of commercial propagation followed under protected cultivation.

Containers

The generally used containers for orchid cultivation are (1) pots, (2) baskets, (3) wooden logs, (4) tree fern blocks, and (5) coconut husk, etc. The containers should have many holes for good drainage and aeration. Pots with both bottom and side holes are a better choice. The pot size may vary from thumb size to 20 inch depending on the type of orchid. Nowadays, plastic pots are also commonly used. Wooden baskets of various sizes and shapes made of high quality wood, which can withstand frequent watering are also chosen by some growers. Generally, square baskets are used.

Potting media

Fig. 2.27: Pots for growing orchids

The media for orchids should have good drainage, aeration and nutrition. In any case there should be no water stagnation. The potting mixture generally used consists of diverse material: brick pieces, charcoal pieces, peat moss, stone pieces or jelly, tree fern fibre, farmyard manure, rock wool plugs, and vermiculite, etc. The compost used is brick pieces, stone pieces, and coke mixed in equal proportions (1:1:1). Different media for epiphytic orchids are osmunda fibre, red wood fibre, perlite, coarse peat moss, gravel, tile pieces, brick pieces, charcoal, coconut husk, etc. Media should be a good supporter for the orchid plants rather than supplying only nutrients.

Whole coconut husk, after removing the coconut, can be utilised for growing orchids. They can be kept hanging from the roof. Terrestrial orchids can be grown on sphagnum moss, tree fern fibre, perlite, charcoal, loamy soil, leaf mould, rice husk, river sand, saw dust, etc. An ideal medium should preferably be inert, resistant to organic decomposition as well as porous to ensure adequate aeration and drainage. It should be less costly and easily available. A mixture of different components mentioned above can also be used.

Fig. 2.28: Potting mixture

Planting and Aftercare

Shallow planting should be done in the containers and support should be given using bamboo sticks or any such pegs.

Watering

The maintenance of adequate humidity is highly essential for successful orchid growing, as the plant absorbs moisture from the atmosphere. Excess water is more damaging than less water. Over watering leads to disease infestation and also affects aeration, hence it should be avoided. If the medium contains coconut husk, tree fern fibre or sphagnum moss, less frequent watering is needed. During the summer months frequent watering is needed. Media should not be too wet or too dry. Mist irrigation or fogger method is ideal to maintain humidity in the atmosphere. The quality of water is also important. High salt content in water adversely affects growth, hence ideal pH level of water should be 5.5–6.5.

Shade regulation

Basically orchids are shade loving plants, hence partial shade should be provided for the plants by installing shade net (50–75 per cent) inside the greenhouse.

Feeding of orchids

Orchids require large quantities of nutrients for their growth and development. Since, the media contains little or negligible quantities of nutrients, their regular application becomes essential. The quality and frequency of application depends on the stage of development, season and type of orchid. Usually, foliar application is more effective. The demand for nitrogen is more during the initial period of growth or vegetative phase. Phosphorus and potassium are required for initiation of flowering and production of a larger number of good-sized flowers. A fertiliser combination containing NPK @ 3:1:1 during the vegetative phase and the same at the proportion of 1:2:2 during the flowering phase is an ideal nutrition for orchids. This can be applied at 0.2 per cent level twice a week. The dose can be changed

according to the plant health, season, stage of growth, etc. Usually, the fertiliser requirement is low during the rainy season.

Apart from the inorganic fertilisers, organic manures like cow dung, neem cake, groundnut cake, etc., are to be applied once in a month. It is better to use fermented cakes (groundnut, sunflower, safflower, etc.) by soaking them in water (1 kg in 10 litres of water) for three to four days and diluting 10–15 times by adding water and applying to the plants. While spraying, care should be taken to avoid the fertilisers from falling on the flowers and inorganic fertiliser application should be stopped three to four days prior to flower harvest. Some essential elements like magnesium, iron, zinc, manganese, etc., also have their roles in the growth and flowering, hence they should be applied once in a month. Growth regulator application, especially BA and GA @ 50–100 ppm also gives good results for enhancing growth and flowering in orchids.

Repotting

Frequent repotting is not required in orchids. When the medium is broken into very small pieces, leading to poor aeration and drainage, then repotting should be done. Also, when the plants are overgrown, then repotting is needed. The original media components can be reused after treating with a fungicide if they are in good condition. Repotted plants should be kept in shade for some days and manuring should be commenced only after some time.

Harvest

In general, orchid flowers do not mature until three to four days after they open. Hence, flower spikes are harvested when 75 per cent of the flowers are open and the remaining buds are still unopened along with a long stem. Harvesting should preferably be done in the evening and the harvesting tools should be sterilised. Immediately after harvesting, the lower 0.75 cm stalk should be cut off. Keep the bases of the flowers in a tube containing fresh water with floral preservative.

Post-harvest Handling

Grading

Grading should be done based on the spike length of the flower, number of flowers per stem and size and arrangement of flowers on the spike.

Floral preservatives

Though long lasting, using floral preservatives on orchids enhances their quality and extends their vase life. Floral preservatives can be applied in two ways.

(1) Pulsing solution
(2) Holding or vase solution

Pulsing solution

Pulsing refers to short duration, pre-shipment or pre-storage treatment of orchids. The effect lasts throughout the entire vase life of the flowers. The main component of pulsing solution is sugar (sucrose). Since pulsing involves short duration treatment, relatively higher level of sucrose is used.

8-Hydroxy quinoline citrate (8-HQC) 500 ppm + sucrose 5% for 12 hrs

Holding or vase solution

The level of sucrose in vase solutions is, therefore, also kept very low (0.5–2 per cent), due to long duration for which flowers are kept in the following solution:

Silver nitrate ($AgNO_3$) 25 ppm + 8-HQC 400 ppm + sucrose 2%

Packaging

Stem bases should be tied in water soaked cotton wads and flowers wrapped in polyethylene wrapper (50 gauge). Then the flowers should be packed in corrugated telescopic boxes. Cymbidium spikes are often packed 100 flowers in a box.

Storage

Tropical and subtropical orchids, for example, Dendrobium can be stored at more than 10°C for two weeks. Temperate orchids such as Cymbidium can be stored at –0.5 to 4°C.

Yield

8–10 spikes/plant/year

Pest and Diseases

Common pests of orchids include aphids, mealy bugs, scales, slugs, snails, spider mites and diseases like black rot, leaf spot, petal blight, virus, etc.

Practical Exercise

Activity 1

Visit a nearby orchid growing greenhouse and make a herbarium of different orchids grown there.

Material required: Writing material and herbarium file

Procedure

- Identify an orchid cultivating farmer.
- Collect leaves, flowers and other parts of plants, press dry and prepare a herbarium.

Activity 2

Note down the observations on common cultural operations carried by a farmer.

Material required: Writing material and practical file

Procedure

Note down the following observations:

- Number of plants per sq.m
- Name of variety
- Colour of flowers
- How they harvest the flowers
- Expected yield

Check Your Progress

A. Fill in the blanks

1. The optimum humidity for most of the orchids is around _____ per cent.
2. Commercial method of orchid propagation is _____.
3. Flower spikes of orchid crops are harvested when _____ of the flowers are open.
4. The temperature requirement for warm orchids is _____ and _____ during the day and night, respectively.

B. Multiple choice questions

1. Containers used for growing orchids are _____.
   (a) pots
   (b) baskets
   (c) coconut husk
   (d) all of these
2. Potting media for orchid should provide _____.
   (a) aeration
   (b) drainage
   (c) nutrition
   (d) all of these
3. Ideal pH level of water should be _____.
   (a) 4.5–5.5
   (b) 5.5–6.5
   (c) 6.5–7.5
   (d) 7.5–8.5
4. Orchids are _____.
   (a) shade loving plants
   (b) shade hating plants
   (c) both
   (d) none

C. Subjective questions

1. Why should we go for shade regulation in orchid cultivation?

   _____

   _____

   _____

2. Which are the common pests and diseases of orchids?

   _____

   _____

   _____

3. What are the important uses of orchids?

   _____

   _____

   _____

D. Match the columns

A	B
1. Sucrose	(a) Propagation
2. Coconut husk	(b) Disease
3. Back bulbs	(c) Pulsing
4. Black rot	(d) Growing media

Session 5: Protected Cultivation and Package of Practices for Lilium

The genus lilium (*Lilium michiganense*) is a herbaceous, bulbous flowering plant belonging to the family Liliaceae. Lilies are one of the most beautiful and precious cut flowers, highly valued for their beauty all over the world.

Fig. 2.29: Greenhouse cultivation of lilium

Different Factors for Lilium Cultivation

Irrigation water quality

Lilium requires good quality irrigation water having EC 0.5–1 dS/m. The maximum acceptable free chlorine level in irrigation water used for greenhouse irrigation should be 2 m mol/L.

EC — Electrical Conductivity

dS/m — decisiemens/m

Temperature

They grow mostly in cold and humid areas, mainly in deep forests naturally. They require low temperature in the range of 12–13°C for the development of roots. During the cultivation stage, the optimum daily temperature requirement is between 15 to 22°C.

Humidity

For optimum growth of lilies, relative humidity inside the greenhouse should be 80–85 per cent.

Light intensity

Lilium plants grow optimally under high light intensity. A dimly lit greenhouse can affect the lilium crop

adversely. Therefore, opening and closing of silver net inside the greenhouse is more important in case of lilium crop, depending on the time of year, the location of production, sunlight in the greenhouse and the variety. At times additional lighting may even be essential because insufficient light results in inadequate growth and bud drop.

CO_2

CO_2 higher than normal in microclimate around the plants ranging from 800–1200 ppm induces their good development. High CO_2 level during early hours of the day is preferred, therefore, closing the side curtains of the greenhouse in the evening and opening early in the morning around sunrise helps in the growth of the plants.

Shading net

Lilium requires a good amount of light for optimum growth and quality of flowers, but intense radiation is best avoided to prevent leaf scorching and poor flower quality and freshness. In such a situation, shade nets of 30–50 per cent capacity come in handy to reduce light intensity depending upon the region and season. It is better to devise a chain and pulley system to spread or roll back the shade net as and when demand and situation arises.

Ventilation

Since greenhouses have a tendency to heat up, especially during intense solar radiation during summer, it is always advisable to devise mechanisms and operations to lower the temperature to prevent the crop from dehydration. It is impossible to get quality lilium flowers under moisture stress. Greenhouses should have proper ventilation at the top and the sides preferably by a forced air ventilation mechanism. The side curtains should be opened by 9–10 am. The height of the greenhouse, top and side ventilation is very crucial. The side and top ventilation depends on the design and size of the greenhouse.

Bedding Media

Soil

Soil should be sterilised and should possess good aeration. For Asiatics and longiflorum varieties, the pH should be 6–7; for Oriental hybrids, a pH of 5.5–6.5 is preferred. Chlorine in the soil should not exceed 1.5 m mol/L.

Bed composition

Soil should be prepared thoroughly because raised beds cannot be shifted, puddled or mixed with inputs as and when desired during planting. A ratio of soil, FYM, sand (6:3:1) with a moderate amount of rice husk and a little river sand should be added for preparing the beds.

Bed preparation

Beds should be approximately 100 cm in width and 25–30 cm in height. There should be a 50 cm path between the two beds.

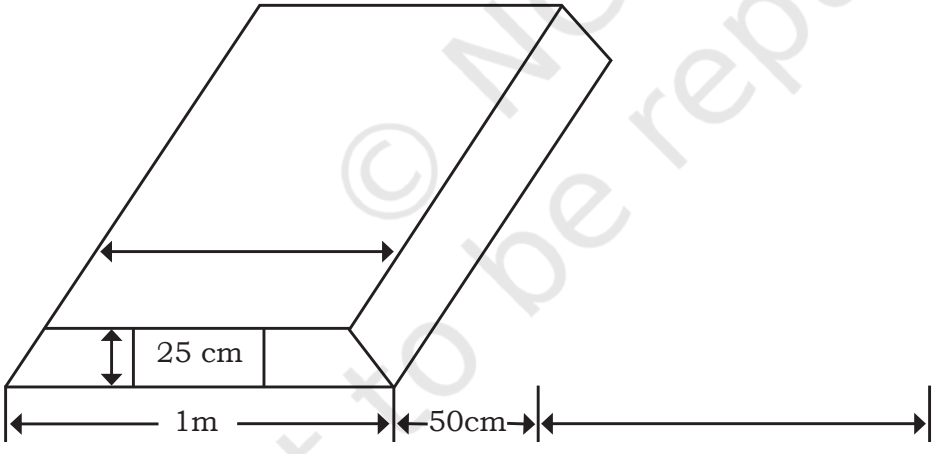


Fig. 2.30: Layout for bed preparation

Mulching

Silver black mulching is ideal for lilium. The silver side on the top repels the sucking pests while the black side helps in discouraging the growth of weeds. Therefore, mulching helps in clean cultivation and avoidance of the use of weedicides.

Pollyanna

Fig. 2.31: Asiatic lilium varieties

Varieties and Commercial Types

Asiatic hybrids *(L. x. elegans)*

Asiatic hybrids are derived from Central and East Asian species. The varieties are Brunello, Elite, Latoya, Tresor, and Navona. Flowers of hybrid varieties are medium in size, upright and outward facing, mostly unscented.

Oriental hybrids

These are hybrids of *L.auratum* and *L.speciosum*. They have fragrance and the flowers tend to be outward facing. The flowers may be quite large and the plants tend to be tall. The varieties are Acapulco, Sorbonne, and Simplon.

LA hybrids

These are a cross between Longiflorum lilies and Asiatic hybrids. Warmer flower colours are found in the Asiatic traits. The upright calyx causes the flower heads to face upward. These have a longer vase life. The varieties are Serrada, Courier, Menorca, and Brindisi.

Plant Spacing and Planting Depth

The bulbs can be planted on a 1 m wide bed in six rows with spacing of 15 × 15 cm for small bulbs of 8–12 cm diameter and 16 × 18 cm for bigger bulbs (12–14 cm diameter). With this spacing, about 25–40 bulbs per m^2 greenhouse area can be accommodated. The planting depth of bulbous

(a) Cv. Detroit

(b) Cv. Brunello

(c) Cv. Pollyanna

(d) Cv. Brindisii (LA) *(e) Cv. Lateya (LA)* *(f) Cv. Elite*

Fig. 2.32 (a, b, c, d, e and f) : Lilium cultivar

flowers is often very crucial and alters the sprouting, uniformity, and the quality of flowers. The ideal planting depth is 6 inches. Planting depth varies according to the size of the bulb. In general, bulbs are planted at a depth of three times more than the diameter of the bulb. After planting of the bulb and irrigation, the soil declines about an inch. The height of the bulb is approximately one inch, which leaves four inches of soil on top of the bulb. This is sufficient soil for the roots to develop.

Fig. 2.33: Asiatic lilium propagation

Irrigation

The soil has to be thoroughly moistened. Planting can be done only when the moisture is ideal because the root initiation has to start from the planted bulbs as soon as possible. Moisten the soil a few days before planting to

enable rooting to start immediately after planting. After about 3–4 weeks of planting, start regular irrigation with about 3 to 4 L/m^2/day. During other seasons, 2 to 3 L/m^2/day is the required quantity of water to be given.

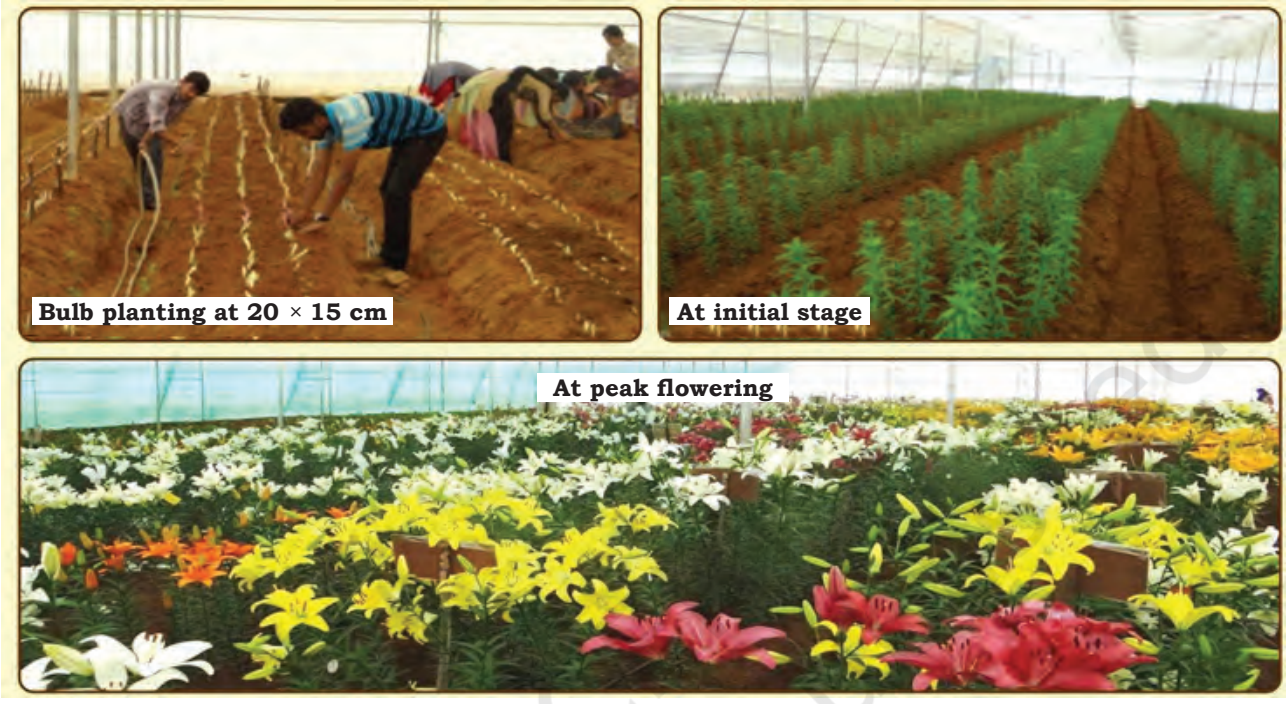


Fig. 2.34: Growing of Asiatic lilium

Fig. 2.35: Drip irrigation in lilium

Fertigation

Bulbous crops harbour most of the nutrients required for plant growth. Lilium is also a bulbous crop, but it is very sensitive to salt, therefore, avoid extra dosage as it can worsen salt deposition. Due to the presence of food

reserves in the bulb, hardly any nutrients are required in the initial one month from an external source. Besides, root development at the initial stages is always more important, so phosphorus supply should be rich for the first three months of the crop. The following schedule of basal dosages or through fertigation should be maintained.

- First three months: 12:61:00 @ 2 kg/100 sqm
- Three weeks after planting: Calcium nitrate @ 1 kg/m^2
- Six weeks after planting: Potassium nitrate @ 1 kg/m^2

The following fertigation scheduling through drip irrigation should be maintained in the lilium growing greenhouses. Mixed micronutrient formulations (25–50 ppm) should also be given fortnightly.

Table 2.5: Month-wise fertigation schedule for lilium under protected cultivation (1000m^2)

Particulars	Month-wise application of water soluble fertilisers (kg/1000m^2)												
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Irrigation nos.	4	6	8	6	8	8	6	6	6	8	6	4	76
Urea phosphate	1.3	1.7	2.7	2.3	2.6	2.7	1.7	1.5	1.8	2.1	2.2	1.4	24.0
Urea	1.5	1.7	2.7	2.3	2.6	2.7	1.7	1.5	1.8	2.1	2.2	1.4	24.0
SOP	1.8	2.5	3.7	3.4	3.8	3.9	2.5	2.2	2.6	3.1	3.1	2.0	34.6

Source: Hasan et al. 2010. *Fertigation Scheduling for Horticultural Crops*. Technical Bulletin. TB-ICN: 80/2010, p. 44, I.A.R.I., New Delhi.

Forcing in Lily Flower Cultivation

Forcing is a way of encouraging a bulb to bloom in an unusual time of the year. Lilium bulbs often require cold treatment of 2–4°C for 1–2 months for Asiatic and Oriental hybrids. This is why 'frozen-in' lily bulbs kept in a refrigerator at 8–10°C for pre-cooling can be used for off season flowering.

Harvesting and Post-harvest Treatment for Flowers

Liliums should be harvested when the buds are fully formed and cutting should be done about 10 cm from the base. The colour of the flower must become apparent from the bud at the time of harvesting. Grading of stems should be done based on the bud size, quality, length,

and firmness of the stem. The basal foliage of the stem is removed and the stem sticks are then sleeved with cellophane or a soft plastic net. After this, the flowers are bunched together and stored at 2–3°C. The base of the stem is provided with a swab of water containing 2 per cent sucrose and 100 ppm GA_3 for preservation. Protection from infestation can be avoided by adding a few drops of preservative. Perforated boxes are used for shipment of flowers through a cold chain, preferably a refrigerated van.

Fig. 2.36: Packaging of lilium

Harvesting of Bulbs and Treatment

Irrigation frequency is reduced before harvesting because too much moisture in the bulbs could lead to their rotting. At the same time, the bulb scales should not dry out. After harvesting the flowers, the bulbs are retained in beds for four to five weeks till the stems have

dried out completely. Then the bulbs are lifted out and dried in the shade. After removing the dried stems carefully, the bulbs are treated with a fungicide, carbendazim @ 2–3 g/L of water and then dried in the shade. Physical damage to the bulbs must be avoided at all costs and should always be treated with fungicide and bactericide. Excessive drying must be avoided. The bulbs are then stored in sterilised cocopeat in crates in a shaded place and stored in cold storage at 2–3°C and then at –1°C for six weeks.

Fig. 2.37: Harvested bulb

Practical Exercise

Activity 1

Make a list of the varieties of lilium grown in your region.

Material required: Writing material

Procedure

- Note down the varieties and the colours available in the market.
- Note down the packing material.

Check Your Progress

A. Fill in the blanks

1. In general, bulbs of lilium are planted at a depth of _____ times more than the diameter of the bulb.
2. The optimum depth of planting a lilium bulb is _____.

3. Lilium (*Lilium michiganense*) belongs to the _____ family.
4. The ideal mulch for lilium is _____.

B. Multiple choice questions

1. Closing the side ventilation at night increases the concentration of _____ in naturally ventilated polyhouses.
   (a) O_2
   (b) CO_2
   (c) Both (a) and (b)
   (d) None of the above
2. Lilium flowers are stored at _____ temperature.
   (a) 8–10°C
   (b) 10–15°C
   (c) 4–6°C
   (d) 2–3°C
3. The fungicide used to treat bulbs is _____.
   (a) Carbendazim
   (b) Sulphur
   (c) Mancozeb
   (d) None of the above
4. For optimum growth of liliums, the relative humidity inside the greenhouse should be _____.
   (a) 65–70 per cent
   (b) 80–85 per cent
   (c) 85–90 per cent
   (d) 90–95 per cent

C. Subjective questions

1. Write about the bed composition and preparation for liliums.

   _____

   _____

   _____

2. Write a short note on fertigation in liliums.

   _____

   _____

   _____

D. Match the columns

A	B
1. Reduce the light intensity	(a) Chlorine
2. Three weeks after planting	(b) Calcium Nitrate
3. Six weeks after planting	(c) Shading net
4. Water treatment	(d) Potassium Nitrate

Unit 3

Special Horticultural Practices in Protected Cultivation

Apart from general field operations, cut flowers need special practices for enhancing quality produce and its production. The special operations include bending, pinching, topping, thinning, disbudding, de-suckering, defoliation, etc. Growth regulators such as Auxins, Gibberellins, Cytokinin, Abscisic Acid, etc., are also used for enhancing the growth and quality of flower production. In this unit, these special horticultural practices in flower cultivation are discussed along with their application method.

Session 1: Special Horticultural Practices in Rose Cultivation

In protected cultivation, the special horticultural practices are:

Thinning

It is the removal of inward growth, weak stems, blind shoots and crowded growth, etc.

De-suckering

It is the removal of suckers from the rootstock. The shoots produced below the bud union on the rootstocks are called suckers and the process of removing them is known as de-suckering.

Pinching

It is done by removing the terminal growing portion of a stem. It is done to reduce the plant height and to promote auxiliary branching. Pinching of a blind shoot is beneficial to increase flowering.

Fig. 3.1: Disbudding in rose

Disbudding

It is the process of removing undesirable buds. Keeping only the central bud, by removing other buds, helps in the development of quality flowers. It is done in standard/HT roses to reduce the number of flowers.

Deshooting

It is the removal of unwanted lateral shoots arising on the terminal shoot. This process is generally followed in HT roses.

Defoliation

It is the removal of leaves from the rose plants. It has been reported that this increases the number of blind shoots. It is followed under special conditions. It forces the plants to produce growth and flowering during the desired period.

Use of Growth Substances

Growth substances like GA_3 and retardants like CCC are used to get more flowers of good quality. GA_3 @ 250 ppm has been found to reduce the number of blind shoots, increase the stalk length and flower size.

Removal of Faded Flowers

It refers to the process of removing old flowers. If opened blooms are not removed in time, there is a chance of developing fruit bearing seeds.

Bending

In bending, the mother-shoot is bent nearer to the crown region or on the second leaf. This happens when, after planting, two to three eye buds sprout on the main branch. These sprouts grow as branches and these branches form buds. The ground shoot or the first

bottom break starts coming from the base. The basic framework for production is done by these ground shoots. They should be cut at the fifth pair of leaves, and the medium ground shoots should be cut at second or third pair of leaves. This helps in the development of a good plant structure. Following this, only weak and blind shoots should be selected for bending. It is a continuous process, carried out throughout the life cycle. Bending helps in maintaining enough leaf area on the plant.

Bud Caps

These are generally placed on the buds when they attain pea size. This helps to increase the bud shape and size to meet the customer demand.

Fig.3.2: Rose bud capping

Practical Exercise

Activity 1

Demonstrate bending operation in roses.

Material required

Planting material, secateurs

Procedure

- Selection of plant
- Selection of shoot
- Bending at a desired length in a particular angle

Check Your Progress

A. Fill in the blanks

1. Removal of a part of a terminal growing portion of a stem is called _____.
2. Removal of unwanted buds is known as _____.
3. Removal of suckers from the rootstock is known as _____.

B. Multiple choice questions

1. Removal of leaves from plants is known as _____.
   (a) de-shooting
   (b) defoliation
   (c) disbudding
   (d) pinching
2. The process of removal of undesirable parts like inward growth, weak stems, blind shoot and crowded growth is known as _____.
   (a) thinning
   (b) de-suckering
   (c) disbudding
   (d) pinching
3. Growth regulator GA_3 helps to increase the _____.
   (a) stalk length
   (b) flower size
   (c) both (a) and (b)
   (d) none of the above

C. Subjective questions

1. Why should we go for bending in roses?

   _____

   _____

   _____

2. Make a list of different special field operations to be followed in rose cultivation and explain any one.

   _____

   _____

   _____

D. Match the columns

A	B
1. Bending	(a) Disorder
2. Blind shoot	(b) Removal of undesirable buds
3. Disbudding	(c) Mother shoot

Session 2: Special Horticultural Practices in Carnation Cultivation

Notes

Support Material

- Carnation crop needs support while growing because it has a tendency to bend due to its weak stem.
- The best material to give it support is a metallic wire woven with a nylon mesh.
- A metallic wire is tied around the bed along the length of the bed with supporting poles.
- Every two metres, the wire is supported with poles. The poles should be strong enough to provide support at the end of each bed.
- Optimum support can be achieved by increasing the width of the meshes, wherein the bottom net can be 7.5 × 7.5cm/10 × 10cm, two nets of 12.5 × 12.5cm and the upper most net of 15 × 15cm dimensions.
- The first layer (bottom net) should be laid before planting. Subsequently, the remaining layers should be spread when the plant grows.
- Before planting, 4–5 layers of nets should be laid for support.
- The wires should be supported with poles at every 2.5 to 3.0 m.
- The first net should be fixed at 12 cm above the soil.
- The remaining nets should be placed over the first net, 15 cm apart.

Pinching

- Pinching means removing the terminal stem and encouraging the growth of the side shoots.
- Pinching should be done of the first six pairs of the leaves.
- The first pinching should be done three to four weeks after planting. The pinched portion gives rise to 4–6 well grown laterals, which are to be allowed.

- Depending upon the need of the crop spread, it is classified into— single, one and a half, and double pinch.

Single pinch

- The ideal time for pinching is in the morning.
- The first pinch is given when the plant attains six nodes.
- An apical portion of 5–7 cm should be pinched off.
- This gives rise to 4–6 lateral shoots.

One and a half pinch

After single pinching, half of the re-arisen side shoots are pinched off again.

Double Pinch

- All the lateral shoots should be pinched off three to four weeks after the first pinch.
- The second pinching is done at four well-developed pairs of leaves.

Disbudding

Disbudding means removing unwanted buds.

For standards

These have a single large flower on an individual stem used as a cut flower.

- Remove lateral buds.
- A single main flower bud is left.

For sprays

Spray carnation is generally a bunch of flowers on short branches of a single stalk. The flowers are small and compact on each branch.

- To encourage more side shoots, terminal or main buds are removed.
- Disbudding should be done when the apical bud is 15 mm in diameter.

Practical Exercise

Activity 1

Visit a carnation cultivation greenhouse and observe the different special horticultural practices followed there.

Material required: Writing material

Procedure

- Visit a carnation greenhouse.
- See the supporting net provided for the crop.
- Draw sketches of the supporting system.
- Identify the buds that should be disbudded.

Check Your Progress

A. Fill in the blanks

1. In carnation, _____ is commonly used to support the plant.
2. The number of net layers laid in carnation is _____.
3. Pinching in carnation is done _____ weeks after planting.

B. Multiple choice questions

1. Disbudding of spray carnation should be done when the apical bud is _____ in diameter.
   (a) 5 mm
   (b) 10 mm
   (c) 15 mm
   (d) 20 mm
2. Which of the following operations is not related to carnation cultivation?
   (a) Pinching
   (b) Disbudding
   (c) Bending
   (d) Supporting

C. Subjective questions

1. Differentiate between single and double pinch in carnation.

   _____

   _____

   _____

NOTES

2. What is disbudding? How does it differ in types of carnation?

_____

_____

_____

3. How is supporting done for carnation plants?

_____

_____

_____

D. Match the columns

A	B
1. GI mesh or Nylon mesh	(a) Increase flower size
2. Disbudding	(b) Supporting
3. Pinching	(c) Increase yield

Session 3: Plant Growth Regulators, Types and their Role

The use of Plant Growth Regulators (PGRs) is well established. Some plant species cultivars or species are responsive to some PGRs, but not all.

A substance produced in one part of the organism and transferred to another part of the same organism, which affects a specific physiological function is known as hormone.

IAA — Indole-3-acetic acid
IBA — Indole-3-butyric acid
NAA — Naphtalene acetic acid
2, 4-D — 2,4-Dichlorophenoxyacetic acid
GA — Gibberellic acid

Types of PGRs

Auxins

Auxins are a group of organic chemicals other than nutrients, which in small quantities or concentrations have the capacity to induce cell division, enlargement, and elongation, root promotion, and flower initiation. They are naturally present in anthers, embryo, and the apical bud of the plant. IAA is a natural auxin and IBA, NAA and 2, 4-D are synthetic ones.

Gibberellins

Gibberellins are organic substances other than nutrients, which in small quantity, are characterised by

the capacity to induce cell elongation, sex modification, dormancy breaking, etc. There are more than 100 forms of GAs but the most common type is GA_3.

Cytokinins

Its natural occurrence is in the form of zeatin. Coconut water is a rich source of cytokinins. The synthetic form available is kinetin. Cytokinin promotes cell division (or cytokinesis) and elongation.

Ethylene

It is known as a ripening hormone. Ethylene triggers ripening but does not participate in the process. It also causes flower opening and leaf fall. Ripe fruits are good sources of ethylene. Ethrel or Ethephon is the synthetic form of ethylene.

Inhibitors

Plants contain many inhibitory substances, which inhibit processes such as seed germination, shoot growth, flower set, fruit set, seed set, etc. Abscisic Acid (ABA) is generally present in the matured and senescing or ageing tissues.

The role of PGRs in floriculture is:

- Plant propagation
- Plant morphological control
- Breaking or prolonging dormancy
- Regulation of flowering
- Improvement of spike and flower quality
- Weed control
- Increasing the yield of flowers, bulbs, corms and cormels
- Extending the vase life of flowers
- Senescence inhibition

PGRs can induce the above mentioned responses dramatically in very minute quantities. The response to PGRs, however, varies with the cultivar, age of the plant, light, temperature, availability of mineral nutrients, vigour of the plant and its endogenous hormonal content.

Practical Exercise

Activity 1

Prepare a list of PGRs (Plant Growth Regulators) and write their use in flower crops.

Material required: Writing material and a practical notebook.

Procedure

- Prepare a list of different PGRs used in flower crop cultivation.
- Write the trade name of different PGRs available in the market.
- Write down the use of PGRs in flower crop cultivation.

Check Your Progress

A. Fill in the blanks

1. A natural auxin is _____.
2. PGR _____ are responsible for cell elongation and sex modification.

B. Multiple choice questions

1. _____ is known as a ripening hormone.
   (a) Auxin
   (b) Gibberellins
   (c) Ethylene
   (d) Cytokinin
2. Abscisic acid is generally present in the _____ tissues.
   (a) newly grown
   (b) matured and ageing
   (c) primary root
   (d) None of these

C. Subjective questions

1. What are plant growth regulators? How can they help the farmers?

   _____

   _____

   _____

2. List the different types of plant growth regulators.

   _____

   _____

   _____

3. List the role of plant growth regulators in floriculture.

_____

_____

_____

D. Match the columns

A	B
1. Cytokinins	(a) Ethylene
2. Auxins	(b) GA_3
3. Ripening	(c) Zeatin
4. Gibberellins	(d) IBA

SESSION 4: METHOD OF APPLICATION OF GROWTH REGULATORS

Different methods of application of growth regulators have been discussed in this session. Among these methods, spraying technique is the most commonly used.

Lanolin Paste

Lanolin is a soft fat prepared from animal wool. It is by nature a good solvent for most of the growth regulators. The paste is prepared with fat and the growth regulator, which sticks firmly with the plant part so that the growth regulator used in the experiment does not dry out. Thus, the PGR used in treatment remains in touch with the plant organ for studying its effect.

Direct Immersion Method

Stock solutions may be prepared by dissolving growth regulators in a few ml of 95 per cent ethanol, methanol or any other alcoholic solvent. This solution is diluted as per requirement in requisite concentration. The cuttings or seeds are soaked for 10 to 24 hours in the diluted solution. If rapid action is required, then the concentration in which the cuttings are dipped is increased. The treatment is known as the direct dip or quick dip method, wherein cuttings are dipped for a few seconds only.

Spraying Method

This method is easy to apply since sprays conveniently cover a large area for any material of horticultural use. Diluted solution is sprayed on foliages. The efficiency of PGRs depends on the application of the method and its quantity. For satisfactory response, the specified concentration and spraying at the right stage is necessary. If properly done, a single spray may be sufficient. In some cases, two applications are necessary.

Growth regulators can also be injected into the plant parts with the help of a syringe, particularly for eliciting a local response from the specific target organ or systemic action.

Dust Method

In this method, the PGR is dissolved in absolute alcohol and mixed with a carrier substance like talc, chemical, or bentonite. This is also an easily applicable method for propagation of cuttings or for layering.

Aerosol and Vapour Method

In this method, the auxin solution is mixed with a solvent of low boiling point. It is done better in any cylinder with gas stored on pressure. Thereafter, this mixture of aerosols can be sprayed into the greenhouse through a spray nozzle in the form of mist. Aerosol mist hovers in the greenhouse for a couple of hours and induces requisite action. This method is more suitable for volatile compounds. The use of an electric fan to circulate the gas with aerosols is also effective. The greenhouse should be kept closed for the entire night by which time the auxins are absorbed by the plants. This treatment can be repeated for a few days to get effective results.

Soil Application

Growth regulators can be applied to the soil. Considerable success has been noticed in the effectiveness of auxins as herbicides.

Practical Exercise

Activity 1

Collect the trade names of growth regulators available in the market.

Material required: Writing material, Internet and practical file

Procedure

- Prepare a list of PGRs.
- List their dosages and roles.
- Make a list of their suppliers.

Activity 2

Prepare a stock solution of 1000 ppm concentration.
(Note: 1ppm=1mg dissolved in 1 litre distilled water)

Material required: Volumetric flask, glass container, growth hormone, weighing balance, and ethanol or solvent

Procedure

- Weigh a 100 mg PGR.
- Put it in a glass container.
- Add 3–5 ml of solvent.
- Mix thoroughly to dissolve properly.
- Bring to volume (100ml) with distilled water.

Check Your Progress

A. Fill in the blanks

1. The method of growth regulator application, most useful for propagation through cutting and layering is _____.
2. The most commonly used method of PGRs application is _____ technique.

B. Multiple choice questions

1. _____ is a popular method for promoting fruit setting in a greenhouse.
   (a) Soil application
   (b) Dust application
   (c) Vapour method
   (d) Lanolin paste
2. Stock solutions are made by dissolving growth regulators in a small volume of _____.
   (a) ethanol
   (b) alcohol
   (c) methanol
   (d) All of the above

NOTES

C. Subjective Questions

1. List the different methods of growth regulator application and describe vapour method.

   _____

   _____

   _____

2. Why is spraying technique most commonly used for the application of growth regulators? How is it done?

   _____

   _____

   _____

D. Match the columns

	A	B
1.	PGR dissolved	(a) Animal wool
2.	Lanolin paste	(b) Direct immersion method
3.	Quick dip method	(c) Absolute alcohol
4.	Vapour method	(d) Volatile compound

Unit 4

Control of Insect Pests and Diseases in Flower Crops

Integrated Pest Management (IPM) is an integration of all suitable plant protection measures like cultural, biological, physical and chemical to manage key pests of selected crops below economic threshold levels, keeping in view the profitability of production, health and safety of consumers and sustainability of the environment.

All the decision making problems depend on the baseline studies of the area and dynamic monitoring of pests. IPM in greenhouses is very important considering the sensitivity of the crop, rapid multiplication of pests and high investment of the greenhouse growers.

The basic component of any IPM is monitoring (scouting). Monitoring includes the following:

(1) Making accurate diagnosis of pests and diseases and related crop injury.
(2) Determining the level of pest incidence.
(3) Recording crop stage and habitat analysis including natural enemies present and the management measures already taken, being taken or can be taken possibly.
(4) Recording all the field observations and their possible relation with pest incidence.

Monitoring helps in decision making. It helps in early warning of the presence of pests and diseases. This enables adoption, execution and monitoring of pest management measures, failing which, the pests or diseases escalate and cause greater losses. IPM is based on holistic data through an appropriate agro-ecosystem analysis including the pervading habitat, natural enemies and other natural suppression mechanisms in operation. Thus, IPM is a holistic and ecosystem-based strategy. In this unit, the techniques for identifying the pests and diseases along with the symptoms and their management practices and important physiological disorders of flowers are discussed.

Session 1: Monitoring and Management of Pests and Diseases

A weekly monitoring programme is ideal for most greenhouse situations. More frequent monitoring may be deemed necessary for high value crops or for pest-prone or pest-infested areas. Crop monitoring tools like sticky traps or plugs should be inspected every three to four days. The person inspecting them should have thorough knowledge of the pest complex for the specific crop varieties and have some basic education in plant and pest biology including major diagnostic symptoms. Standard protocols for selected crops may be prepared along the prevalent patterns for monitoring and diagnostics. Any pre-determination should be counter-checked with the observations and recorded thereby. Sampling of the greenhouse should be in standard zig-zag manner to avoid personal and observational bias but not avoiding the infested patches. Diseased or pest infested areas must specifically be observed on the periphery and centre also.

Pest Monitoring Techniques

To monitor pests in a greenhouse, various pest monitoring techniques are available. The type of technique selected will largely depend on the crop, its stage of growth and the situation against which it needs protection. Some pests are always present and

can be monitored using conventional methods such as sticky traps or visual observation of plant parts. Some unique monitoring methods, which are pest-specific, are required such as the use of pheromone traps.

Visual observation

If the pest scout is to diagnose the pest visually and directly, then it is the best confirmation. Stage of a crop, part of the plant or soil or indicator plants also confirm the presence of a pest. Sucking pests that do not fly, for example, mites or immature stages of other pests or the disease symptoms can be located using this technique. On the other hand, flying pests like whiteflies, and aphids can be located using sticky traps besides direct visualisation. As discussed above, observation should be done following a zig-zag pattern and random selection of plants. Visual observation is subjective and competence dependent, hence, it is advisable that the same person monitors the crop throughout the season.

Sticky traps

Pests monitored regularly, especially sucking pests, which multiply rapidly can be controlled by using blue sticky traps (thrips), yellow sticky traps (aphids/ whiteflies) and pheromone traps with lures for moths of caterpillars. Sticky traps like yellow sticky traps or blue sticky traps are common tools of observation and monitoring of small flying insects such as whiteflies, thrips, leaf miners, psyllids, aphids and leafhoppers, by the pest scouts or growers. They are very simple and economical and easily available in the market. The growers can also make the sticky traps on their own by using simple yellow or blue polythene stuck on boards and pasted with sticky glue or grease on which flying insects can easily get stuck. These traps are also available in triangular hut-shaped 'delta traps'. They are particularly helpful in double door greenhouses, which not only helps in monitoring the pests but also in checking their entry into greenhouses through the doors during workers' movements.

Pheromone traps

Insects secrete pheromones to alert other insects about information such as trail location, the sex of the insect and alarm. Synthetically produced pheromones mimic the chemicals produced by insects and are used to lure specific insect species for specially designed traps. Easy to use and inexpensive, species-specific, and environmentally safe characters make pheromone traps one of the ideal tools for IPM programmes. However, large-bodied insects like borers rarely enter a greenhouse so the use of pheromone traps in greenhouses has little relevance.

Fig. 4.1: Yellow sticky trap (Delta trap)

Fig. 4.2: Pheromone trap

Baseline Studies

Baseline studies are carried out even before the fabrication of a greenhouse so as to understand the situation of the farm, common pest problems of the area, management techniques and tools, and diagnostic or technical support available in the area. Such a study helps in preparing for future problems of plant protection that would require attention.

Accurate Identification of Pests and Diseases

In a pest management programme, it is very important to accurately identify the pest, insect, weed, plant disease, or vertebrate animals. This step is essential for taking appropriate and effective IPM decisions.

In addition, the damage is not always caused by pests; sometimes these problems are due to environment or nutritional disorders that cannot be remedied with pesticides. If the problems are incorrectly diagnosed, inappropriate chemical treatments used will be ineffective and would incur unnecessary expenditure besides causing environmental degradation. Once the pest has been identified accurately and confirmed that it is causing damage, one has to get familiarised with its life cycle, habitat, time and location of occurrence, and reproductive habits to work out the weak or vulnerable stages for its management. Pests may leave signs of their presence or symptoms of damage on the hosts and this can help in pest identification. Pest symptoms include discoloration, insect feeding indicators or reduced plant growth due to competition with weeds for nutrients.

Therefore, implementation of IPM involves the following stages.

(1) Baseline studies

(2) Preventive measures, including quarantine (such as site selection, crop rotation, sanitation and crop hygiene, summer ploughing and solarisation, removal of weeds and alternate hosts, crop geometry and habitat, timely sowing or transplantation, balanced fertigation, biodiversity and habitat management, soil health management, removing stubbles of old crop and residues, hygiene and weed management around greenhouses and maintain natural enemy population)

(3) Monitoring, scouting and diagnosis

(4) Integration that is, active pest management (physical, chemical, biological control, bio-rational pest management, etc.)

Proper IPM implementation also includes review of measures taken and proper and safe disposal of pesticide bottles, polythene, etc., away from children, water bodies and animals. Worker safety tips should also be provided for using chemicals and equipment safely.

Notes

Practical Exercise

Activity 1

Study different types of traps such as light, pheromone and yellow sticky traps.

Material required: Writing material, camera and different types of traps

Procedure

- Take photos of different traps.
- Label the different parts of the traps.
- Prepare a brief report on their utility.

Check Your Progress

A. Fill in the blanks

1. A basic component of IPM programme is _____.
2. Monitoring serves as an early warning system for the presence of _____ and _____.
3. The most common way to determine the presence of pests on plant parts is _____ observation.

B. Multiple choice questions

1. Traps that mimic the pheromones of insect species are _____.
   (a) light traps
   (b) pheromone traps
   (c) sticky traps
   (d) None of the above
2. Microorganisms that can cause a reduction in plant health include _____.
   (a) fungi
   (b) bacteria
   (c) virus
   (d) All of the above

C. Subjective questions

1. What is IPM?

   _____

   _____

   _____

2. What is monitoring and what does it include?

   _____

   _____

   _____

3. How do sticky traps and pheromone traps help in pest management?

_____

_____

_____

D. Match the columns

A	B
1. Baseline study	(a) Sucking pest
2. Microorganism	(b) Scouting
3. Sticky traps	(c) Holistic status of field and crop
4. Monitoring	(d) Disease

Session 2: Management of Pests and Diseases

In this session, the management practices of major pests and diseases along with their symptoms are being discussed with a focus on flower crops cultivated under protected cultivation.

Rose and Gerbera

Name	Symptoms	Control measures (chemicals may be used as per CIBRC guidelines and registration compliances)
Pests		
Mites	Pests which are present in large colonies on the underside of the leaves, covered with fine silky webs. White specks that appear on the leaves coalesce and appear as white patches due to their feeding. Ultimately, the affected leaves become mottled, dry, stiff and shiny. Plants grow weak and pale.	Spraying horticultural oil or other biorational oils like neem or azadirachtin with plain water helps. Sulphur dusting also helps. For chemical control, Dicofol @ 0.5 ml/L or Abamectin @ 0.25 ml/L should be sprayed.
Aphids	Large, dark green or pink brown aphids feed on buds, shoots and leaves. Foliage of infested plants is fouled with sticky honeydew and sometimes with sooty moulds and the plant growth may be checked.	Excessive use of nitrogenous fertilisers should be avoided. Light dusting with Pyro dust or spraying Nuvacron may be helpful. Systemic insecticides like dimethoate @ 2 ml/L or Imidacloprid 0.3 ml/L should be sprayed to control aphids. Spraying of nicotine sulphate may also help.

Thrips	Flower buds may become deformed and fail to open due to high population of thrips on roses. Petals could be covered with brown streaks and spots. Western flower thrips can act as vector for certain tospovirus including impatiens necrotic spot virus and several strains of tomato spotted wilt virus. They affect the top parts of the plant.	Systemic insecticides like Thiamethoxam @ 0.3 g/L or Imidacloprid @ 0.3 ml/L or dimethoate (1.7 ml/L) should be sprayed to control thrips.
Leaf miner	This insect makes zig-zag mines inside the leaves, which make the leaves turn from yellow to brown.	Strict monitoring should be done. Leaves should be plucked as soon as tunnels are noticed in the leaves. The infected plants should be destroyed. Spraying Cypermethrin or Dichlorvos (0.5–0.75 ml/L) controls leaf-miner.
Diseases		
Die-back	This is the most serious disease of the rose plant in India. Die-back implies the death of the plant from top downwards indicating drying of the twigs. The pruned surface of the twigs is the first to get affected by this disease.	The diseased stem has to be cut about 5–7 cm below and the cut wound must be treated with copper sulphate or Bordeaux paste or after mixing it in cow dung. Over watering should be stopped especially under humid conditions. Cuttings should be procured from certified nurseries only. Drench the soil with carbendazim @2 g/L to control the disease. Spraying captan or mancozeb @ 3 g/L or copper-oxychloride @ 3 g/L immediately after pruning and then twice at 10 days interval is effective to control the die-back of the rose.
Black spot	The disease is characterised by the development of black circular spots of 2–12 mm on the upper leaf surfaces.	The infected leaves should be pruned and burnt. Preventive spraying of carbendazim @ 2 g/L must be done at fortnightly intervals.
Powdery mildew	It is a major disease of protected cultivation including rose. The disease affects all the aerial parts of the plant, but the leaves are more prone to it. The younger leaves curl and become purplish in colour. The leaves develop raised blister like areas and get coated with the white powdery growth of the fungus.	The infected plants should be sprayed with wettable sulphur at the rate of 3 g/L of water at fortnightly intervals. Fungicides like Triadimefon, Fenarimol, Penconazole may be tried.
Collar rot	The symptom is noticed at the soil surface on the collar portion of the stem. In severe cases, the leaves turn yellow and the entire plant wilts.	Drench the soil either with metalaxyl @ 2 g/L or with contact fungicide such as captan (2 g/L) or copper oxychloride at the root zone of the plants. Drenching with Fosetyl-Al also helps.

Root rot	Several fungi, namely Pythium sp., Sclerotium rolfsii and Rhizoctonia solani affect the root system of gerbera and other protected cultivation crops particularly at the initial stage.	Sterilise the soil before planting and regularly apply fungicide like copper oxychloride @ 3 g/l to the soil to control the disease. Drenching with Fosetyl-Al also helps.

Orchids

Name	Symptoms	Control measures
Pests		
Mealy bugs	Cottony masses especially infest the junctures such as the crook between two leaves. Stunting of plants can be noticed.	During early infestation, remove the affected region with a cotton swab dipped in methylated spirit. On severe infestation, use an insecticide containing malathion or nicotine.
Scales	This is a round or oval shell in brown, grey or white colour often accompanied by a sooty mould. The plant may be stunted, leaves may turn yellow and fall off.	Pick the infested part with a knife or tweezers or swab with methylated spirit. Spraying of adult scales with an insecticide containing malathion or nicotine also helps.
Slugs and snails	The plant is punctured with ragged holes, and a slimy trail is visible from where the pests have passed.	A tuft of cotton wool around the stem protects the flowers. Trap snails and slugs with pesticide bait containing metaldehyde or methiocarb @ 4–10 g/m^2 or lure slugs at night into a saucer of beer to drown them.
Spider mites	Leaves appear pitted or striped with white. Webs can be noticed.	To break the webs, spray foliage with warm water. Spray heavy infestations with pesticide containing dicofol @ 0.5ml/L or abamectin @ 0.25 ml/L.
Diseases		
Black rot	Purplish blotches edged with yellow discolouration appear on leaves and new shoots. Rotting may occur both in acropetal and basipetal succession.	Water plants in the morning, avoid watering foliage during hot weather, choose resistant variety of roses, encourage air circulation, keep the greenhouse clean and remove dead leaves, take up preventive management. Drench infected plants with a fungicide such as captan or zineb @ 2–3 g/L. Remove infected parts, cut 2.5 cm into the healthy tissue and seal the cuts with fungicide. Destroy severely infested plants.
Leaf spot	Raised or sunken spots in yellow, brown or purplish colour appear on the leaves. They spread quickly. Leaves turn yellow or brown and die in the advanced stages.	Increased air circulation and low humidity is beneficial. Cut off diseased leaves; spray with fungicide. Apply captan or a systemic fungicide containing thiophanate-methyl 2–4 g/L weekly.

Petal blight	Small brown circles, often with pink edges, appear on the sepals and petals. Sometimes burnt symptoms may be noticed.	Destroy infected blossoms. Spraying with a fungicide containing captan, thiophanate-methyl, thiram or zineb also helps.
Virus	Leaves show yellow, black or brown pitting, mottling, and streaking. The flowers may also be streaked or mottled.	There is no remedy. Destroy the infected plants by burying or burning. The hands and tools of the workers may spread the viral disease in the entire greenhouse. When dividing, sterilise the knife over a flame between cuts, or dip potting sticks in 10 per cent bleach solution may also help. Control aphids, which are also vector for virus transmission by spraying proper systemic insecticides like dimethoate (1.7 ml/L) or acetamiprid or spinosad to control the sucking pests that spread infestation.

Fig. 4.3: Powdery mildew on rose

Fig. 4.4: Aphid on rose

Fig. 4.5: Thrips infected rose

Fig. 4.6: Black spot on rose

Fig. 4.7: Orchid mealy bugs

Fig. 4.8: Orchid slugs and snails

Fig. 4.9: Orchid leaf spot

Important note

The use of chemical pesticides has to be done only as per CIBRC guidelines and registration compliances. These are a must and binding.

Practical Exercise

Activity 1

Visit a nearby pesticide shop and collect trade names of different chemicals available in the market.

Material required: Writing material and practical file

Procedure

Enlist the following:

- Insecticides (formulation and expiry date)
- Fungicides (formulation and expiry date)
- Weedicide (formulation and expiry date)

Activity 2

Prepare a herbarium of different diseased plant samples.

Material required

Writing material, newspaper or blotting paper, herbarium sheets

Procedure

- Take the diseased leaves.
- Try to identify the disease.
- Press between the blotting paper or newspaper for a week.
- Remove sheets of blotting paper and stick the sample in a file and label it.

Check Your Progress

A. Fill in the blanks

1. Pests, which are minute in size and found in large colonies on the underside of the leaves covered with fine silky webs, are _____.
2. Honeydew is secreted by_____.
3. Insect vectors for tospovirus are _____.
4. When the leaves develop raised blister like areas and get coated with white powdery growth of fungus, these are the symptoms of _____.

B. Multiple choice questions

1. The chemical abamectin is sprayed against _____.
   (a) bacteria
   (b) fungi
   (c) mites
   (d) ants
2. Black spots can be controlled by spraying _____.
   (a) dimethoate
   (b) abamectin
   (c) carbendazim
   (d) imidacloprid
3. Dieback is the most serious disease of _____.
   (a) carnation
   (b) orchid
   (c) rose
   (d) gerbera

C. Subjective questions

1. List the pests and diseases of flower crops.

   _____
   _____
   _____

2. How will you manage thrips and mites in a greenhouse?

   _____
   _____
   _____

3. How will you manage mealy bugs?

   _____
   _____
   _____

4. How will you manage soil-borne diseases?

_____

_____

_____

5. How will you manage plant viruses?

_____

_____

_____

D. Match the columns

A	B
1. Root rot	(a) Sooty mould
2. Aphids	(b) Brown streaks and spots
3. Die-back	(c) Disease of rose plant
4. Thrips	(d) Pythium

SESSION 3: PHYSIOLOGICAL DISORDERS OF FLOWER CROPS

Plant disorders often result from nutritional deficiency, improper cultivation practices or storage situations. Unfavourable temperature, humidity, pH, other abiotic stresses, erratic water or nutrient supply, poor light, and stressful atmosphere, cause deficiency or unthrifty growth and physiological disorders or deformities in flower crops.

Rose

Blind shoot

A common occurrence is the failure to develop a flower on the apical end of the stem. Such shoots are termed as blind. The sepals and petals are present, but the reproductive parts are absent or aborted. Reasons for this are various, such as insufficient light, chemical residues, insect-pests, fungal diseases and other factors.

Bull heads or malformed flowers

The centre petals of the bud remain partly developed and the bud appears flat. This is due to the lack of carbohydrates.

Colour fading

Off-coloured flowers cause a problem. In some yellow varieties, the petals may be dirty white or green instead of a clear yellow. Rise in the night temperature by several degrees cause reduction in the number of off-coloured flowers.

Limp necks

Limp necks is when the area of the stem just below the flower 'wilts' and is not able to support the head. Sometimes, this is due to insufficient water absorption. Cutting off 1 to 2 inches of the lower stem and placing the cut stem in water at 37°C revives the flower.

Blackening of rose petals

Blackening is caused by high anthocyanin content in the flowers and low temperature. This effect is less pronounced at high temperature (30°C during the day and 20°C at night) than in low temperature (20°C during the day and 4°C at night). In other words, low temperature and high anthocyanin content may cause blackening of rose petals.

Nutritional disorders

Iron deficiency can cause pale foliage (interveinal chlorosis of younger leaves). pH adjustment in the soil or application of $FeSO_4$ (0.5%) may solve this problem.

Carnation

Calyx splitting

The calyx may split either partially or completely, depriving the petals of their support, which results in bending of petals. Thus, the regularity of shape and structure of the flowers is disturbed. Splitting

is associated with light and it occurs when the temperature fluctuates. Splitting can be reduced by keeping the night temperature from 10–15°C. High plant density causes more calyx splitting. High dose of nitrogen reduces the number of split calyces while increase in the potassium rate enhances it. Varieties tolerant to calyx splitting are Palmir, Epson, etc.

Curly tip

This disorder affects the growing tips mainly, which curl and become distorted. The tips of young shoots fail to separate and the continuation of growth results in a typical curvature. Poor light and other adverse conditions are thought to be the causes of the disorder. Water stress and potassium deficiency are suspected causes for physiological die-back and curly tip of the carnation flowers.

Gerbera

Bushiness

An abnormality characterised by short petioles, small laminae and numerous leaves, which gives some cultivars of gerbera a bushy appearance, is known as bushiness. No internode elongation is seen and the nodes are also not clearly distinguished.

Stem break

This is mainly caused by water imbalance. It could be ethylene associated early senescence and linked with water stress. It is a common post-harvest disorder in cut gerberas.

Yellowing and purple margin

Yellowing and early senescence of leaves occurs due to nitrogen deficiency, while phosphorus deficiency causes the flower to turn pale yellow with a purple margin. Increase in levels of nitrogen and phosphorus promotes the development of suckers and improves flowering in gerbera.

Practical Exercise

Activity 1

Collect pictures and samples of physiological disorders of flowers.

Material required: Writing material and practical file

Procedure

- Collect samples of physiological disorder of flowers, branches or leaves, etc.
- Write down the symptoms of the physiological disorders of flowers and control measures in brief.
- Take their photographs and paste them in a brief report.

Check Your Progress

A. Fill in the blanks

1. Colour fading is very common in _____ coloured rose varieties.
2. Blackening of rose petals is due to _____ and high _____ content.
3. Curly tip is a common disorder of _____.

B. Multiple choice questions

1. Bull head is a common disorder of _____.
   (a) gerbera
   (b) rose
   (c) carnation
   (d) orchid
2. Calyx splitting is a common disorder in _____.
   (a) carnation
   (b) rose
   (c) gerbera
   (d) lilium

C. Subjective questions

1. Define plant disorder.

   _____

   _____

   _____

2. List the important disorders of rose.

   _____

   _____

   _____

3. What is calyx splitting in carnation? How can it be controlled?

_____

_____

_____

D. Match the columns

A	B
1. Calyx splitting	(a) Rose
2. Blind shoot	(b) Gerbera
3. Stem break	(c) Carnation

NOTES

Unit 5

Harvesting and Post-harvest Management

Pre and post-harvest practices influence cut flower quality and longevity. About 20–40 per cent of the cut flowers produced are lost due to improper post-harvest handling or management. This loss can be reduced by careful harvesting, post-harvest handling, sanitation, temperature management, and judicious use of floral preservatives.

Session 1: Stage of Harvesting

General Guidelines of Harvesting

The maturity of the cut flower decides its post-harvest life. Based on purpose, the flowers must reach the right stage of development before harvesting. Most of the cut flowers are harvested early in the morning or late in the afternoon. Flowers are harvested with a sharp knife or secateur. The following points must be kept in mind for harvesting.

- The stage of harvest varies according to the species. The proper stage of openness is a critical factor in vase life. Flowers will have a shorter vase life if they are cut at their peak stage of development.
- Alternatively, flowers harvested too tight will not attract customers, because they may never open.

- Several other factors, such as the plant species, cultivar, weather conditions, distance from the market place and end use, play an important role when flowers are harvested.
- Harvesting of flowers early in the morning after the dew drops dry, is beneficial. The stems are still filled with water and the cooler morning temperatures prevent heat from building up in the bunches.
- While harvesting, keep in mind that a high-quality product is essential for success and should be graded accordingly.
- A clean, sharp knife or clippers should be used for cutting. Immediately after harvesting the stems, they should be placed in a clean bucket filled with tepid, clean water and preferably a floral preservative.
- The buckets full of flowers should be placed in a cool, shaded spot or even better, in a cooler environment, until they are marketed. Freshly cut flowers should be put in the floral preservative solution for at least two to three hours before they are sold.

Harvesting of Different Flower Crops

Rose

Harvesting is done when the flower is at the tight bud stage, the colour is fully developed and the petals have not yet started unfolding.

Carnation

Standard carnation flowers are harvested at the paint brush stage when the flowers are nearly half open whereas spray cultivars are harvested when two flowers are fully opened on the stem.

Tight bud stage *Paint Brush* *Cross Bud* *Fully Opened*

Fig. 5.1: Harvesting stages of different flower crops

Orchids

Flowers are harvested when they are fully open. Flowers cut prior to their maturity will wilt before reaching the wholesaler.

Lilium

Harvest the lilies when they attain a height of 8 to 10 cm above the ground level and the lower first bud shows the colour of the flower. Prevent the stems from drying out during and after harvesting. After harvesting, grading should be done according to the number of flower buds per stem, length and firmness of the stem.

Practical Exercise

Activity 1

Visit a nearby polyhouse and observe different harvesting operations.

Material required: Writing material and practical file

Procedure

- Note down the flower crops grown in the polyhouse.
- Observe the time and stages of harvesting of flowers.
- Observe harvesting and collection methods in particular crops.

Check Your Progress

A. Fill in the blanks

1. About _____ per cent of the cut flowers produced are lost due to improper harvesting and post-harvest handling.
2. Cut flower quality and longevity mainly depend on _____ and _____ practices.

B. Multiple choice questions

1. The right stage for harvesting of cut rose flowers is _____ stage.
   (a) tight bud
   (b) slight bud open
   (c) half bud open
   (d) full bud open

2. Harvest the lilies when they attain a height of _____ cm
   (a) 2–7
   (b) 15–20
   (c) 8–10
   (d) 20–25

C. Subjective questions

1. List the factors that play an important role in harvesting of flowers.

   _____

   _____

   _____

2. Why should harvesting be done in cool temperature?

   _____

   _____

   _____

3. List the correct stage of harvesting in different flower crops.

   _____

   _____

   _____

D. Match the columns

A	B
1. Tight bud	(a) Carnation
2. Paint brush	(b) Orchids
3. Fully open	(c) Rose

SESSION 2: PRE-COOLING

Pre-cooling

Freshly harvested flowers have their own physiological processing, adjusted to the high rate of transpiration. To check this, pre-cooling is done to alter it and make the plant comfortable at a lower temperature by pre-cooling and removing the field heat. Pre-cooling is done by keeping the still unpacked flowers or bunches in the boxes at a lower temperature for 6–8 hours in winter and 10–12 hours in summer. This brings down the physiological, respiration and transpiration rate, thereby making the plant lose less moisture, enabling it to remain fresh for a longer duration after cutting.

Methods of pre-cooling

Air cooling: Cold air is passed over unpacked boxes or on conveyor belts through coolers.

Forced air cooling: Cold air is forcibly passed over ventilated boxes with a certain number of holes, which allows cooling of the produce kept inside. Forced air cooling method is commonly used for pre-cooling of flowers.

Hydro-air cooling: A fine mist of water is mixed with forced air for more effective cooling.

Pre-cooling temperature for different cut flowers

Cut flowers	Pre-cooling temperature (0°C)
Gerbera	2
Rose	1 – 2
Carnation	1
Cymbidium	0.5 – 4.0
Cattleya	7.0 – 10.0

Pulsing

Pulsing is a procedure that provides conducive conditions to flowers to supply nutrients and requisite water to cut flowers. It is achieved by keeping the harvested flowers in a solution containing high concentration of sucrose and any selected germicide for a short period to improve the shelf life and to promote flower opening. While sucrose provides energy, water in the solution helps in keeping the flowers fresh. Germicide keeps the solution infection free or else the flower base rots. This operation is particularly important when flowers are stored for a longer period for distant transportation.

Light intensity is measured in terms of lumens per square meter or lux. Lux meter device is used to measure light intensity.

Thus, pulsing is a simple procedure that can be easily done by growers, wholesalers or retail florists to lengthen the post-harvest and vase life of flowers in water. Pulsing should be done at 22–24°C temperature with light intensity of around 2000 lux. It prolongs the vase life, promotes bud opening and also improves the colour and size of the flower petals. Pulsing is particularly crucial when the flowers have to be shipped farther.

Post-harvest Handling of Cut Flowers

NOTES

Rose

Roses are harvested and packed in bunches but before that they are kept in a bucket of water so that the heat of the field is removed effectively. After this, bunching is done along with wrappers. These are stored in cold storage at 2–4°C. The duration of storage of the roses depends on the variety and quality. Then the flowers are graded according to their length. Variation in grading is about 40–70 cm and it also depends on the variety. Packing is done in a bunch of 20 flower sticks each.

Carnation

Carnation is a very delicate flower that tends to bend. Hence, utmost care has to be taken in its transport to the market or export purposes. After harvest, the flower stems are trimmed at 2" from the base and put immediately in a bucket of a preservative solution of warm and de-ionised water. Flowers are kept in a preservative for two to four hours and then placed in a cold room (0–2°C) for 12–24 hours. The flowers can be stored for two to four weeks before marketing. Cartons used for shipment should have ventilation holes and also be lined with polythene to prevent the flowers from collapsing. The packed cartons should be pre-cooled without a lid. Then plastic should be loosely folded on top of the stems and after that the final lid should be placed. These cartons should be stored in cool chambers maintaining a temperature of 0°C and good air circulation. Relative humidity must be maintained between 90–95 per cent in the cool chambers.

Gerbera

Harvesting of gerbera is done when the outer two to three rows of disc florets are perpendicular to the stalk. The heel for the stalk should be cut about 2–3 cm above the base and kept in fresh chlorinated water.

Orchids

Although orchids are very delicate, yet compared to other flowers they can survive for a very long time after harvest.

They are often grown in pots and transported as such, but if they are harvested, they should be stored in cold rooms at 4–5°C and can be safely kept for 10–15 days. They can also be wrapped in plastic films of different colours and design to make them more attractive.

Grading

Grading refers to an assortment of flowers on the basis of their quality, shape and marketable values. Grading of flowers is based on the following criteria:

- Each bunch should be as uniform as possible in size, weight and quality before marketing them.
- The flowers should appear fresh, harvested at the right maturity stage and free from deformities and infestation of pests and diseases.
- The stems should be straight, free from side shoots and strong enough to hold the flower erect.
- There are no uniform common standards for flowers in the world. Many countries have developed their own grading systems based upon the market requirements.

Packaging

Packaging is another important aspect in the flower trade. Packets should be air-tight, small in volume, waterproof and strong enough to withstand handling. A wet cotton swab may be put on the cut end of the flower stem which is wrapped in polythene to help maintain humidity. The wetting of the swab may also be done using some preservative to avoid infection.

Packing Methods of Flowers

Flowers are one of the most valuable products of agriculture. The market of flowers from the local shops, to traders and exporters is highly variable. Packing plays a crucial role in making the flowers still more attractive while also taking care of their shelf or vase life and safety during shipment. The main idea behind packing is slowing down of the physiology of the plant including the rate of transpiration and respiration, so that the flowers retain as much moisture and freshness as possible. While pre-cooling is done as

discussed above, packing has to be linked with pre-cooling and transport. Corrugated fibre board (CFB) boxes are widely used for packing for their light weight, isothermic properties and reusability. The dimensions of packing boxes depend on the type of flower, its stem length, efficient utilisation of space in the cargo and refrigerated trucks, etc. Wet packing for orchids, anthurium; polyethylene foil or sleeve cover for gerbera, chrysanthemum and anthurium; and special packing for exotic flowers and orchids are required. The packed boxes are cooled by forced air cooling method where vents are provided on the boxes (4–5 per cent) for passing cool air onto the flowers wrapped in polyethylene foil.

Box sizes that are commonly used for packing flowers are:

Flower	Length (cm)	Width (cm)	Height (cm)	Weight (kg)
Carnation	100	40	20	13
Rose	100	40	30	17

Types of Packaging

(1) Primary packaging: In this, the product is placed directly in the material, wrapper or basket, etc., such as, wrapping materials (paper or polythene), vases, bouquets, carton, crates, etc.

(2) Secondary packaging: In this, the outer wrapping is used to store, transport and display while at the same time protect the product, such as CFBs, decorated carton, gift boxes, perforated boxes, etc.

(3) Tertiary packaging: In this, the assorted groups or clusters of products are kept for storage and transportation, such as pallet boxes, CFBs, cartons, plastic or wooden boxes.

Transport

The flowers are usually transported in air-cooled containers. For short distances and local markets, rail transport or non-refrigerated insulated trucks can be used. The whole system is referred to as cold-chain or cold-value-chain. The flowers vulnerable to bending

of tips, for example, gladiolus, lilium, etc., should, therefore, be stored vertically and well supported before their transport.

Practical Exercise

Activity 1

Visit any nearby farmer's field or greenhouse and collect information about packaging, storage and transportation.

Material required: Writing material

Procedure

- Visit a nearby farmer's field or greenhouse and collect information about the packaging of cut flowers.
- Discuss and note down all the practices after harvest and before packaging.

Activity 2

Identification of different types of packaging material

Material required: Writing material and packaging material

Procedure

- Identify different types of packaging material.
- Draw a packaging box of the exact measurement.
- Label the box with dimensions of each side.
- Also mark the places where holes are supposed to be in the boxes.

Check Your Progress

A. Fill in the blanks

1. Pre-cooling removes _____ from freshly harvested flowers.
2. _____ method is commonly followed for pre-cooling of flowers.
3. _____ refers to the categorisation of flowers on the basis of their shape and quality.

B. Multiple choice questions

1. Keeping the flowers in a solution containing a high concentration of sucrose and germicide for a short period is called _____.
   (a) pulsing
   (b) pre-cooling
   (c) holding
   (d) air cooling

2. Forcing cold air through ventilated boxes is called _____.
   (a) hydro cooling
   (b) forced air cooling
   (c) air cooling
   (d) pre-cooling

C. Subjective questions

1. List the qualities of an ideal package.

   _____

   _____

   _____

2. What is pre-cooling and how is it done?

   _____

   _____

   _____

3. What is the optimum temperature for storage of different flower crops?

   _____

   _____

   _____

4. What are the different types of packaging?

   _____

   _____

   _____

D. Match the columns

A	B
1. Sucrose	(a) Packaging
2. CFB box	(b) Pulsing
3. Refrigerated van	(c) Transport

NOTES

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 counter-productive 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.

NOTES

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.

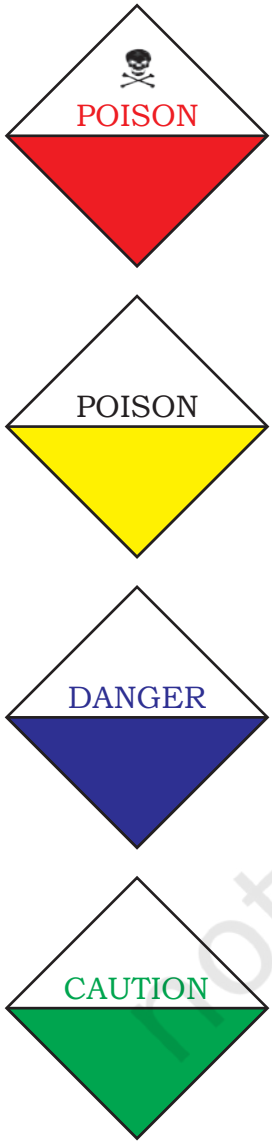


Fig. 6.1: Labels of colours showing toxicity of pesticide

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.

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.

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.

Fig. 6.2: Safety apparel for preparing spray solutions

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

Fig. 6.3: Caution signage while pesticide spraying

Fig. 6.4: Signage for pesticide applied at field

- 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.

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

get emptied. Use a strong nozzle to triple rinse or pressure rinse the metal, plastic, or glass containers, unless otherwise instructed on the label. get

- 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 may be washed with plenty of water, keeping the eyelids open. A quick decisive action is

desirable as delay of a few seconds may greatly increase the extent of the injury. Refer to an eye doctor immediately.

(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 may be 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.

Hand gloves

Always use rubberised waterproof gloves, not ones made of leather, cotton, or any fluid-absorbing material.

Fig. 6.5: Hand-gloves and headgear

Shoes

The shoes made of rubber or any synthetic waterproof material are used instead of leather or canvas shoes.

Fig. 6.6: Protective clothing

Eye shields

These must be worn to prevent eye poisoning.

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.

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.

_____

_____

_____

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.
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.

Notes

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.
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.

   _____
   _____
   _____

NOTES

GLOSSARY

Cladding material: *covering material of the greenhouse that is, polythene, insect proof net, shade net or polycarbonate, etc.*

Clogging: *blockage*

Cocopeat: *growing medium prepared from the dried powder of coconut plant fibres*

Compatibility: *miscibility or mixing ability without precipitation*

Chemigation: *is the application of agricultural chemicals (fertilisers, micro nutrients fungicides, herbicides, insecticides, nematicides, soil conditioners, growth regulators, and biological agents, as well as gray water and animal wastes) into water flowing through an irrigation system.*

Dripper: *water emitting hole in the drip irrigation pipe, also called emitter.*

EC meter: *device to measure the electrical conductivity of water or aqueous phase of soil*

Evapotranspiration: *water loss through transpiration from plants canopy and evaporation from soil surface and expressed in mm/ day.*

Fertigation: *supply of irrigation in combination with soluble fertilisers as per required dosages and frequency.*

First-aid: *assistance given to any person suffering from a sudden illness or injury*

Gutter: *channel for collecting water for run-offs from the roof.*

Hazard: *a potential threat or source of harm*

Hygrometer: *device to measure relative humidity*

Micronutrient: *nutrients required by plants in very minute dosages or in traces only.*

Occupational hazards: *hazards experienced at the workplace*

Pan evaporation: *evaporation of water from an open surface recorded at a meteorological station on a daily basis and expressed in mm/day. Under protected cultivation, open field pan evaporation is multiplied by a conversion factor ranging from 0.3–0.6 to know the actual evaporation inside protected structures.*

Poison: *substance capable of causing illness or death.*

Pro tray: *plastic trays used for soil-less production of nursery*

Shade net house: *protected structures are covered by a shade net often on all sides to protect the crop from intense solar radiation.*

Sterilisation: *disinfestation of any medium or container or soil to make it free from infection of bacteria, fungi or other microbes and/or disabling any living entity to reproduce. It is also called ascepticisation.*

Ventilation: *movement or exchange of air across the system or cross aeration*

Walk-in-tunnel: *protected structures covered by polythene, high enough for walking by workers and open on both the ends generally to allow pollination*

NOTES

Further Readings

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Answer Key

Unit 1: Care and Maintenance of Protected Structures

Session 1: Care and Maintenance of Protected Structure Components

A. Fill in the blanks

1. Smoking
2. moving parts
3. side curtains or doors
4. electrician
5. water

B. Multiple choice questions

1. (b) 2. (b) 3. (c) 4. (b)

D. Match the columns

1. (b) 2. (c) 3. (a)

Session 2: Care and Maintenance of Drip Irrigation and Fogging Systems

A. Fill in the blanks

1. clogging problem
2. 7
3. fogger
4. oil paint
5. temperature and humidity

B. Multiple choice questions

1. (b) 2. (b) 3. (a) 4. (d) 5. (c)

D. Match the column

1. (b) 2. (c) 3. (a)

Session 3: Sanitation Practices in Greenhouses

A. Fill in the blanks

1. CO_2
2. rubber

B. Multiple choice questions

1. (d) 2. (b) 3. (b)

C. Match the columns

1. (d) 2. (a) 3. (b) 4. (c)

Unit 2: Protected Cultivation of Rose, Gerbera, Carnation, Lilium and Orchids

Session 1: Protected Cultivation and Package of Practices for Roses

A. Fill in the blanks

1. sandy loam
2. October to November
3. 75
4. 15–28°C
5. budding

B. Multiple choice questions

1. (b) 2. (d) 3. (d) 4. (c) 5. (b)

D. Match the columns

1. (c) 2. (d) 3. (a) 4. (b)

Session 2: Protected Cultivation and Package of Practices for Gerbera

A. Fill in the blanks

1. 200 cut flowers
2. 60,000
3. 2–4
4. South Africa
5. 22–25°C to 12–16°C

B. Multiple choice questions

1. (c) 2. (d) 3. (d) 4. (d)

D. Match the columns

1. (c) 2. (a) 3. (b) 4. (d)

Session 3: Protected Cultivation and Package of Practices for Carnation

A. Fill in the blanks

1. sandy loam
2. 120, 160 days
3. terminal

B. Multiple choice questions

1. (c) 2. (c) 3. (d)

D. Match the columns

1. (d) 2. (a) 3. (b) 4. (c)

Session 4: Protected Cultivation and Package of Practices for Orchids

A. Fill in the blanks

1. 70
2. tissue culture
3. 75 per cent
4. 21°C to 29°C and 18°C to 21°C

B. Multiple choice questions

1. (d) 2. (d) 3. (b) 4. (a)

D. Match the columns

1. (c) 2. (d) 3. (a) 4. (d)

Session 5: Protected Cultivation and Package of Practices for Lilium

A. Fill in the blanks

1. three
2. 6 inches
3. Liliaceae
4. silver black

B. Multiple choice questions

1. (b) 2. (d) 3. (a) 4. (b)

D. Match the columns

1. (c) 2. (b) 3. (d) 4. (a)

Unit 3: Special Horticultural Practices in Protected Cultivation

Session 1: Special Horticultural Practices in Rose Cultivation

A. Fill in the blanks

1. pinching
2. disbudding
3. de-suckering

B. Multiple choice questions

1. (b) 2. (a) 3. (c)

D. Match the columns

1. (c) 2. (a) 3. (b)

Session 2: Special Horticultural Practices in Carnation Cultivation

A. Fill in the blanks

1. supporting net or metallic wire
2. 4–5 layers
3. 3–4

B. Multiple choice questions

1. (c) 2. (c)

D. Match the columns

1. (b) 2. (a) 3. (c)

Session 3: Plant Growth Regulators, Types and their Role

A. Fill in the blanks

1. IAA
2. GA

B. Multiple choice questions

1. (c) 2. (b)

D. Match the columns

1. (c) 2. (d) 3. (a) 4. (b)

Session 4: Method of Application of Growth Regulators

A. Fill in the blanks

1. dust/powder method
2. spraying

B. Multiple choice questions

1. (c) 2. (d)

D. Match the columns

1. (c) 2. (a) 3. (b) 4. (d)

Unit 4: Control of Insect Pests and Diseases in Flower Crops

Session 1: Monitoring and Management of Pests and Diseases

A. Fill in the blanks

1. monitoring/scouting
2. pests, diseases
3. visual

B. Multiple choice questions

1. (b) 2. (d)

D. Match the columns

1. (c) 2. (d) 3. (a) 4. (b)

Session 2: Management of Pests and Diseases

A. Fill in the blanks

1. mites
2. aphids

3. thrips
4. powdery mildew

B. Multiple choice questions

1. (c) 2. (c) 3. (c)

D. Match the columns

1. (d) 2. (a) 3. (c) 4. (b)

Session 3: Physiological Disorders of Flower Crops

A. Fill in the blanks

1. yellow
2. low temperature and anthocyanin
3. carnation

B. Multiple choice questions

1. (b) 2. (a)

D. Match the columns

1. (c) 2. (a) 3. (b)

Unit 5: Harvesting and Post-harvest Management

Session 1: Stage of Harvesting

A. Fill in the blanks

1. 20–40 per cent
2. pre and post-harvest

B. Multiple choice questions

1. (a) 2. (c)

D. Match the columns

1. (c) 2. (a) 3. (b)

Session 2: Pre-cooling

A. Fill in the blanks

1. field heat
2. forced air cooling
3. grading

B. Multiple choice questions

1. (a) 2. (b)

D. Match the columns

1. (b) 2. (a) 3. (c)

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)

List of Credits

Fig. 1.1 (a and b): Naved Sabir, Principal Scientist at Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi

Fig. 2.1 (a): https://tinyurl.com/y2grckd7/

Fig. 2.1 (b): https://tinyurl.com/y3c8glpc

Fig. 2.1 (c): https://bit.ly/2UHuIP0

Fig. 2.1 (d): https://bit.ly/2WQLgX0

Fig. 2.1 (e): https://tinyurl.com/y6b7abmu

Fig. 2.1 (f): https://tinyurl.com/yxlra7xw

Fig. 2.2: https://tinyurl.com/yylcjmsq

Fig. 2.3 (a and b), 2.5, 2.6, 2.7 (a, b and c), 2.8 (a and b), 2.9, 2.10, 2.11, 2.12 2.13, 2.14, 2.15 (a, b and c), 2.16, 2.17, 2.18, 2.19, 2.20, 2.21, 2.22, 2.23, 2.24, 2.25, 2.26, 2.27, 2.28, 2.29, 2.30, 2.31, 2.32, 2.33, 2.34, 2.35, 2.36, 2.37, 3.1, 3.2, 4.1, 4.2, 5.1: Balaji Shreedhar Kulkarni, Professor and Head, UHS Campus, G.K.V.K., Bengaluru, Karnataka

Fig. 2.4 (a): https://tinyurl.com/y4q2d7b2

Fig. 2.4 (b): https://tinyurl.com/y4k7aefr

Fig. 2.4 (c): https://tinyurl.com/y6ry342m

Fig. 4.3: https://tinyurl.com/yxdt8ay4

Fig. 4.4: https://tinyurl.com/y2w3mtct

Fig. 4.5: https://tinyurl.com/yx9zldjh

Fig. 4.6: https://tinyurl.com/y6od67ho

Fig. 4.7: https://tinyurl.com/y5fez6u9

Fig. 4.8: https://tinyurl.com/y6qzqlq6

Fig. 4.9: https://tinyurl.com/yy3mta9n