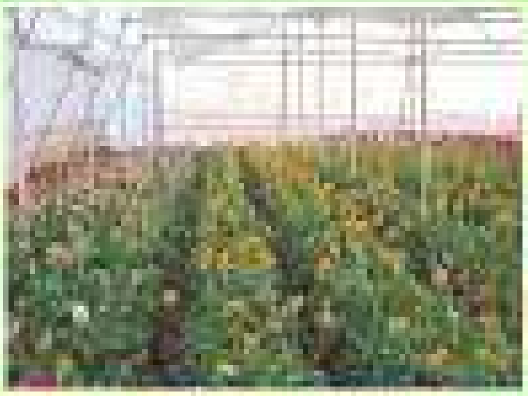



Floriculturist (Protected Cultivation)

(Job Role)

Qualification Pack: Ref. Id. AGR/Q0702

Sector: Agriculture

Textbook for Class XI

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Textbook for Class XI

विद्यया ऽमृतमश्नुते
एन सी ई आर टी
NCERT
राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
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Foreword

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

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

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

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

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

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

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

HRUSHIKESH SENAPATY
Director
National Council of Educational
Research and Training

New Delhi
June 2018

About the Textbook

Agriculture is an important part of India's economy, which accounts for about 18 per cent of 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 the 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 being 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 responsibility also involves maintenance and care of plant, design and maintenance of green house, 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 towards getting 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 the individual, therefore, the learning activities are student-centred rather than teacher-centred.

The textbook has been developed with contributions of the subject experts, vocational teachers and industry experts and academicians for making it a useful and inspiring teaching-learning resource material for the vocational students. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOS) for the job role so that the students acquire the necessary knowledge and skills as per the performance criteria mentioned in the respective NOS of the Qualification Pack (QP). It has been reviewed by experts 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/N0704-Pre-cultivation Operations of Floriculture in the Greenhouse.
2. AGR/N0705-Cultivation Operations of Floriculture in Greenhouse.

Unit 1 of this textbook introduces the importance of protected cultivation, criteria of site selection and suitable crops for protected cultivation. Unit 2 focuses on the types of protected structures, classification of greenhouses and major components of greenhouse. Unit 3 deals with the growing media, its composition, sterilisation of growing media, preparation of beds and containers for growing flower crops. Unit 4 focuses on micro irrigation systems and their application under protected cultivation, fertilisers and their scheduling. Unit 5 deals with the equipment for environmental parameters monitoring in greenhouses, and management of environmental parameters.

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 always welcome.

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

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

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

The contributions of faculty members, Saroj Yadav, *Professor* and *Dean* (A), Ranjana Arora, *Professor* and *Head*, DCS, Aparna Pandey, *Professor*, DESS, Sunita Farkya, *Professor*, DESM, and Abhya Kumar, *Assistant Professor*, Planning and Research Division, CIET of the book review committee are duly acknowledged.

The images used in the textbook have been sourced from the Creative Commons License and Jain Irrigation System Ltd. 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. Credits for Figure 2.10 go to Technical Standards for Naturally Ventilated, Fan & Pad Green House and Shade Net House, Protected Production under NHB Scheme (Technical Standard No. NHB-PH-Type 02-2011), of Department of Agriculture and Cooperation, National Horticulture Board.

Gratitude is also due to the Publication Division, NCERT, for transforming the manuscript into an attractive textbook. Special thanks are due to Shveta Uppal, *Chief Editor*, Madhavi Ratnaparkhi, *Assistant Editor* (Contractual) and efforts of *DTP Operators* Pawan Kumar Barriar, Publication Division, NCERT and Neha Pal (Contractual) are acknowledged for flawless layout design.

Contents

Do You Know?

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

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

Give Girls Their Chance !

Unit 1

Introduction to Protected Cultivation

Introduction

Protected cultivation is a process of growing crops in a controlled environment. This means that the temperature, humidity, light and such other factors can be regulated as per requirement of the crop. This assists in a healthier and a larger produce. There are various types of protected cultivation practices. Some of the commonly used practices are — forced ventilated greenhouse, naturally ventilated polyhouse, insect-proof net house, shade net house, plastic tunnel and mulching, raised beds, trellising and drip irrigation. These practices can be used independently or in combination, to provide favourable environment to save plants from harsh climate and extend the duration of cultivation or off-season crop production. Adoption of drip irrigation under raised beds (you will read about it in Unit 4) covered with mulch films not only eradicates weeds but also maintains moisture in the soil for a prolonged period by minimising evaporation losses.

Session 1: Importance of Protected Cultivation

Although agriculture has been the backbone of India's economy since ages, yet our experience during the last 50 years indicates a relationship between the agricultural practices, its growth *vis-à-vis* economic well-being. The trend of agricultural growth points towards a mix of appreciable achievements on the one hand and missed opportunities on the other. If India has to remain self-sufficient and provide food security to the poor while also being able to export high quality fruits and vegetables, new and effective production technologies are required which can continuously improve the productivity, profitability and respectability of the agricultural sector. One such area is the protected cultivation technology, which is being widely practiced in the developed countries, but its use in India is limited.

Do you know?

Greenhouse effect

When short wave radiation from the Sun enters the greenhouse structure, it refracts through the surface and gets transformed into long wave radiations. These long wave radiations do not escape the greenhouse in entirety, thereby trapping the heat and thus, continually increase the temperature inside. This is known as the greenhouse effect. Thus, the enclosed space builds higher temperature than the ambient environment. However, after sunset it starts losing stored heat through conduction, convection and radiation.

The wide variations in the climatic conditions across the diverse topography through the length and breadth of the country allow a large number of cropping patterns. India also experiences climatic extremes such as floods, droughts and other climatic abnormalities that cause crop losses regularly or damages resulting in economic losses to the farmers. Simultaneously, the demand for quality agricultural produce has increased over the last decade. This provides better opportunities for the Indian farmers to adopt protected cultivation technologies as per region and suitability of the crops.

Greenhouses are being commercially used for production of exotic (non-native) and off-season vegetables, export-quality cut flowers and also for raising quality seedlings. Economic returns from the high value agricultural produce can be increased substantially when grown under greenhouse conditions. For the crops under protected environment, the use of chemical pesticides and insecticides can be kept minimal to avoid their residues on the crop produce. Greenhouses are mostly used as rain shelters, particularly in high rainfall areas of India such as North-eastern states and coastal regions.

Objectives of Protected Cultivation

(i) Protection of plants from abiotic stress (physical or by non-living organism) such as temperature, excess/deficit water, hot and cold waves, and biotic factors such as pest and disease incidences, etc.

(ii) Efficient water use with minimum weed infestation.
(iii) Enhancing productivity per unit area.
(iv) Minimising the use of pesticides in crop production.
(v) Promotion of high value, quality horticultural produce.
(vi) Propagation of planting material to improve germination percentage; healthy, uniform, disease-free planting material and better hardening.
(vii) Year-round and off-season production of flower, vegetable or fruit crops.
(viii) Production of disease-free and genetically better transplants.

At present in India, the small and medium farmers have started flower and vegetable cultivation under different types of modular protected structures depending upon their investment capacity and availability of market in their area. Among all the protected cultivation practices, greenhouse cultivation provides maximum benefits. The major crops grown under protected structures include — floriculture crops like rose, gerbera, carnation, anthurium, lilium, orchids, chrysanthemum, etc., and the vegetable crops like tomato, yellow and red bell peppers (from the capsicum family), cucumber, leafy and exotic vegetables, etc.

Limitations of Protected Cultivation

(i) High cost of initial infrastructure (capital cost).
(ii) Non-availability of skilled human power and their replacement locally.
(iii) Lack of technical knowledge of growing crops under protected structures.
(iv) All the operations are very intensive and require constant effort.
(v) Requires close supervision and monitoring.
(vi) A few pests and soil-borne pathogens are difficult to manage.
(vii) Repair and maintenance are major hurdles.
(viii) Requires assured marketing, since the investment of resources like time, effort and finances, is expected to be very high.

Scope of Protected Cultivation

As per the National Horticultural Database of the year 2014–15, Tamil Nadu ranks first in area under flower

NOTES

cultivation followed by Karnataka, and West Bengal. The share of floricultural products in the export of total horticultural produce is 3.2 per cent. At present the share of Indian floriculture products in international market is about 0.6 per cent. According to (APEDA) data, in the year 2016–17, India's total export of floriculture was Rs 548.74 crores. Dry flowers alone contribute around 70 per cent revenue of the total floricultural export. India has a share of 10 per cent of the total global dry flower market. There are over 300 export-oriented Floriculture Units in India, mostly located near Mumbai, Pune, Bengaluru, Hyderabad and New Delhi, which have good facility for expert of live plant material for producing and exporting flowers to the developed countries. The export-quality flowers include bulbs, cut and loose flowers, dry flowers, ornamental plants and cut foliage, which are most suited for greenhouse cultivation. Besides this, greenhouse technology holds premise for marginal farmers for higher productivity and quality through high technology based agriculture.

While greenhouses did exist in one form or the other for more than one-and-a-half centuries in various parts of the world, the use of greenhouse technology started in India only during 1980s mainly for research activities, after India had achieved self-sufficiency in foodgrain production. After the 'Green Revolution', some of the ill consequences like extensive use of chemicals in fertilisers and pesticides of intensive agriculture became evident.

Besides the government's efforts, globalisation has given a boost to the export of agricultural produce, which has played a role in the increased demand for greenhouses in most parts of the country.

Commercial production of floriculture exists in Maharashtra, Tamil Nadu and Karnataka, which cater to the demands of both domestic and foreign markets. From 1988 onwards, these ventures have been specialised further to achieve a technological edge involving development of greenhouses. These have improved further post-1991 India when Indian economy was liberalised. At present, the private sector has established 100 per cent export-oriented units. These efforts have been quite successful in meeting export standards for the regularity of supply, quality and hence acceptability in offshore markets. Exports have achieved very promising results in terms of the acceptance of quality standards in major foreign markets.

Table 1.1: Crops Grown under Protected Cultivation

Flowers	Chrysanthemum, Carnation, Gerbera, Rose, Lilium, Orchid, Gladiolus, etc.
Vegetables	Tomato, Coloured Capsicum (Yellow and Red Bell Peppers), Cucumber, Broccoli, Red Cabbage, Leafy vegetables, Radish, etc.
Fruits	Strawberry
Seedling and Nurseries	Vegetables, Flowers, Tissue Culture, Clonal for Forestry, Fruit Grafting (like Lemon, Citrus, Mango, Pomegranate, Guava, Litchi, etc.)

The Government of India executes various schemes for protected cultivation at the central and the state levels to popularise these high-tech plant growing techniques. National agencies through their leading schemes *viz.* National Horticulture Board (NHB), National Horticulture Mission (NHM), Mission for Integrated Development of Horticulture (MIDH) and *Rashtriya Krishi Vikas Yojana* (RKVY) create awareness and provide financial support to the farmers, so that protected farming for high value horticultural crops could be adopted easily.

Protected cultivation involves a complex set of practices and technologies which require elaborate planning, fabrication, management and maintenance of quality production of horticultural crops to take advantage of season, demand and choice of market. It gives opportunities for the cultivation of horticultural crops in an entrepreneurial form for the upmarkets in urban and semi-urban areas, besides empowering youth, and technology-led traditional ways of crop cultivation to such modern methods.

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Practical Exercises

Activity 1: Visit to a greenhouse farmer

Materials required: notebook, pen, pencil, etc.
Procedure: Visit and note down following information

- Collect the information about location/owner.
- Types of structure.
- Cost involved for establishment of protected structure.
- How she/he makes financial arrangement.
- Input required for establishment of polyhouse.

Check Your Progress

A. Fill in the blanks

1. Greenhouse is commonly used to produce ____________ cut flowers.
2. Rain shelters are mostly used in _____________.
3. Year round and off season production of flowers and vegetables is possible in ________.
4. Forced ventilated greenhouse is the type of ____________.

B. Mark the correct choice

1. Protected structure protect the plant against __________ .
   (a) only biotic stress
   (b) only abiotic stress
   (c) biotic and abiotic stress
   (d) water stress
2. Flower crop grown under protected cultivation
   (a) Gerbera
   (b) Jasmine
   (c) Hibiscus
   (d) Marigold
3. Use of greenhouse technology in India started in the year
   (a) 1970
   (b) 1980
   (c) 1990
   (d) 2000

C. Descriptive Questions

1. Describe the importance of protected cultivation.

____

____

____

2. Describe the scope of protected cultivation in India.

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____

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3. What are the objectives of protected cultivation?

____

____

____

D. Match the columns

	A	B
1.	Protected Cultivation	a. Less productivity/unit area
2.	Open Cultivation	b. Temperature stress
3.	Shed net house	c. High productivity/unit area
4.	Greenhouse effect	d. Protected structures

Notes

Session 2: Site Selection and Suitable Crops for Protected Cultivation

While protected cultivation practices such as drip irrigation, raised bed farming, mulching can be practised on any site, even where cultivation is still being done. The criteria for site selection in case of protected cultivation structures like shade net houses and greenhouses are as follows:

(i) Exposure to ample sunlight: The site should not be near tall trees, buildings or by the leeward side of hills.

(ii) Appropriate distance from a low-lying area: The site should not be in an area prone to waterlogging.

(iii) Levelled ground surface: A slope of 0–2 per cent is recommended. Levelling is required to be done in case the slope is beyond the recommended range. For steep terrains, it is recommended to build several separate greenhouses with axes parallel to contour lines.

(iv) pH and electrical conductivity of soil: It should have a pH of 6.0–6.5 and electrical conductivity should be less than 0.5 dS/m.

(v) Availability of continuous source of good quality water in sufficient volume: The approximate water requirement is 1–2 l/m^2/day, which can be adjusted based on the season and the stage of cultivation.

(vi) pH and electrical conductivity of water: The pH and electrical conductivity of irrigation water should be in the range 6.5–7.0 and less than 0.7 dS/m respectively.

dS/m (deci Siemens) indicates the amount of salts present in the soil (K+, Ca+, Mg+, Na+, Cl-, HCO3). Excess amount of salts hinder plant growth and/or can affect infiltration (becoming a part due to filtration).

(vii) Continuous supply of electricity: This is particularly necessary during the day time.

(viii) Good transportation facilities: This is important to enable the transportation of greenhouse produce to nearby markets in time.

(ix) Availability of sufficient land for future expansion: A gap of 10–15 m should be maintained between two greenhouses, considering the possibility of expansion in future.

(x) Easy availability of labourers in surrounding area: This should also be kept into consideration. Usually, four labourers are required for flower cultivation in a one-acre greenhouse.

(xi) Good communication facilities: These should be available at the site.

(xii) Plantation of windbreaks: The plants that breaks the flow of the wind from a particular direction. These plants are tall and have strong root base. These include poplar, silver oak, casuarina, etc., which are planted on the western side about 20 m away from the greenhouse because west winds are the strongest.

Mulch is a protective covering (of sawdust, compost, plastic sheet spread or left on the ground) that is used to reduce evaporation, maintain even soil temperature, prevent erosion, control weeds, enrich the soil or to keep it clean.

(xiii) Awareness of relevant occupational safety and health standards.

Greenhouse Orientation

In a single span or multi-span naturally ventilated polyhouse, the orientation of the structure is in the North–South direction and all roof vents face East, except the last bay, which is in the opposite direction. Also, in a naturally ventilated polyhouse or shade net house, 40:60 ratio, i.e., 40 per cent width (East to West) and 60 per cent length (North to South) is kept for better ventilation, though this ratio is based on the wind load on the North–South wall, in high speed wind zones. If the wind speed is high in an area, the length of the structure is restricted within 55 m in the North–South direction. However, in single or multi-span shade net houses, the longest dimension should be in the East–West direction. In this context, the direction of planting beds is also important and has to be done perpendicular to the arc of the Sun movement through the day.

In open fields, all crop varieties like self-pollinated and cross-pollinated vegetable crops can be cultivated under drip irrigation, raised bed and mulching. However, while selecting the vegetable crops for shade net house and greenhouses, self-pollinated varieties must be selected or at least there should be proper arrangement and expertise for artificial or aided pollination. It is important to note that such restrictions do not apply to flower cultivation. The major flower crops cultivated in greenhouses are — rose, gerbera, carnation, chrysanthemum, lilium, orchids, etc. These crops are propagated either by grafting or based on tissue culture or cuttings.

The varieties are developed by the plant breeders and are mostly patented. The seed propagated varieties are mostly first-generation hybrids. The commercial vegetative propagations of the other crops are done mostly by private firms using tissue culture method. The duration of the crop varies with the type of crop. The crops grown in greenhouse can be cultivated in the soil organic or artificial media.

tissue culture: the growth in an artificial medium of cells derived from living tissue

Major Flower Crops and their Varieties Cultivated under Greenhouses

Rose

The commonly cultivated varieties of rose are as follows.

- Standard rose: This variety bears large-sized buds with long stalk. It has good commercial value for long distance markets due to its higher shelf-life.
- Sweet heart rose: This variety bears small-sized buds with short stalk.

Fig. 1.1: Rose

- Spray rose: The plants of this variety bear five to six buds.

The roses grown in greenhouse could be of different colours and combinations such as red, yellow, white, pale green, pink, orange and their different shades. Some of the commercially available varieties of rose are Gold-strike, Grand gala, Noblesse, Revival, Bordeaux and Avalanche.

Gerbera

Fig. 1.2: Gerbera

Almost all the gerbera plants cultivated in greenhouses in India are commercially tissue cultured varieties and are multiplied and distributed by various private firms. The commonly grown colours of gerbera are white, red, pink, yellow, orange and twin shades.

Some of the commercially available varieties are — North Star, Ornella, Paradox, Tropic Blend, Topaz and Pink Fantasy.

Carnation

Fig. 1.3: Cultivation of Carnation

The commonly cultivated varieties of carnation are as follows.

- Standard carnation: This variety bears longer branches with bigger buds.
- Spray carnation: This variety bears shorter branches and small flowers.

Chrysanthemum

It is one of the commonly preferred cut flowers and potted plants in the domestic and international market. It stands tremendous scope. Private and small entrepreneurs and progressive growers can give impetus to the efforts to develop non-traditional export products to suffice the agricultural sector for earning the much needed foreign exchange. Boost for the commercial production of chrysanthemum will replace import quantity with local production. Selection of chrysanthemum varieties depends on the location and objective of the growers *vis-à-vis* the variations grown *viz.*

Fig. 1.4: Chrysanthemum

Otome (white and pink), Taiwan Yellow, Bowl of Gold, Taiwan White, Golden Princess Anne, etc. For potted chrysanthemum, the varieties grown are Kikubiyori, Snowball, Genie, La France, Rhapsody, Red Headline, Miss Hiroshima, Algiers, Capistrano, Autumn Fire, etc.

NOTES

Practical Exercises

Activity 1: Visit to a polyhouse and record criteria for site selection.

Materials required: notebook, pen, etc.
Procedure

- Visit the place with prior appointment.
- Observe road connectivity, wind breakers, electricity, skilled labour availability, etc.

Activity 2: Visit to a greenhouse flower cultivator and discuss about crops and varieties.

Materials required: notebook, pen, pencil, etc.
Procedure

- Identify the greenhouse flower grower in the nearby area.
- Visit these sites in consultation with the farmer(s).
- Discuss with the farmer on crop cultivation practices and advantages of protected cultivation as perceived by the farmer.
- Assess the need of promoting a particular type of the crop grown in a greenhouse.
- Discuss problems associated with greenhouse.

Check Your Progress

A. Fill in the blanks

1. The soil pH should range between _______ for effective greenhouse cultivation.
2. The gap between one greenhouses to another should be minimum __________ m.
3. Number of labour required for flower cultivation in one acre greenhouse are _____________.
4. Under greenhouse condition ___________ pollinated type of varieties are suitable.
5. Longer branches with bigger bud size varieties of carnation are known as __________.

NOTES

B. Mark the correct choice

1. The direction of single span greenhouse should be
   (a) East–West
   (b) North–South
   (c) North–East
   (d) South–West
2. The windbreaks should be kept in the _________ direction
   (a) Eastern
   (b) Western
   (c) Northern
   (d) Southern
3. What is the ratio of width and length in shade net house?
   (a) 40:60
   (b) 20:10
   (c) 15:25
   (d) 20:80

C. Descriptive questions

1. Write important criteria for site selection in protected cultivation.

   ____

   ____

   ____

2. Which type of roses can be cultivated in protected structures?

   ____

   ____

   ____

D. Match the columns

A	B
1. Gerbera	a. Bear five to six buds
2. Spray roses	b. A protective cover
3. Mulch	c. Taiwan yellow
4. Chrysanthemum	d. Pink Fantasy

Floriculturist (Protected Cultivation)-Class 11- Unit 1 Session 1

A. Fill in the blanks

1. Greenhouse is commonly used to produce __________ cut flowers.
2. Rain shelters are mostly used in ____________.
3. Year round and off season production of flowers and vegetables is possible in _______.
4. Forced ventilated greenhouse is the type of ___________.

B. Mark the correct choice

1. Protected structure protect the plant against _________ .
   (a) only biotic stress
   (b) only abiotic stress
   (c) biotic and abiotic stress
   (d) water stress
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3. Use of greenhouse technology in India started in the year
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C. Descriptive Questions

1. Describe the importance of protected cultivation.

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2. Describe the scope of protected cultivation in India.

____

____

____

3. What are the objectives of protected cultivation?

____

____

____

D. Match the columns

	A	B
1.	Protected Cultivation	a. Less productivity/unit area
2.	Open Cultivation	b. Temperature stress
3.	Shed net house	c. High productivity/unit area
4.	Greenhouse effect	d. Protected structures

Floriculturist (Protected Cultivation)-Class 11- Unit 1 Session 2

A. Fill in the blanks

1. The soil pH should range between _______ for effective greenhouse cultivation.
2. The gap between one greenhouses to another should be minimum _________ m.
3. Number of labour required for flower cultivation in one acre greenhouse are ____________.
4. Under greenhouse condition __________ pollinated type of varieties are suitable.
5. Longer branches with bigger bud size varieties of carnation are known as _________.

B. Mark the correct choice

1. The direction of single span greenhouse should be
   (a) East–West
   (b) North–South
   (c) North–East
   (d) South–West
2. The windbreaks should be kept in the ________ direction
   (a) Eastern
   (b) Western
   (c) Northern
   (d) Southern
3. What is the ratio of width and length in shade net house?
   (a) 40:60
   (b) 20:10
   (c) 15:25
   (d) 20:80

C. Descriptive questions

1. Write important criteria for site selection in protected cultivation.

____

____

____

2. Which type of roses can be cultivated in protected structures?

____

____

____

D. Match the columns

A	B
1. Gerbera	a. Bear five to six buds
2. Spray roses	b. A protective cover
3. Mulch	c. Taiwan yellow
4. Chrysanthemum	d. Pink Fantasy

Unit 2

Types of Protected Structures and their Components

Introduction

So far, we have learnt that protected cultivation aims to modify the micro climate of the plants by selective control of environment for the protection of the crops from biotic and abiotic stresses for healthy and safe crop production, notably all round the year including the off-season. Greenhouses enable qualitative and quantitative production of ornamental crops of high value especially during the off-season for fetching better prices, that otherwise is not possible through open field cultivation. This is particularly helpful in cold areas with heavy snowfall or chill factors.

Different types of protected structures can be adopted for off-season and round the year cultivation of flowers and ornamental crops. Commonly used protected structures are — low tunnels, walk-in tunnels, net houses, greenhouses and mist chambers. These structures vary in their shape, design, height and size.

Session 1: Types of Protected Structures

In India, protected cultivation technology for commercial production is hardly three decades old. In a country like ours, where most of the structural designs have been adopted from different countries, the designs have been amply modified to suit the local conditions and requirements of different agro-climatic areas. The commonly used protected structures are as follows.

Low Tunnel

Also called 'miniature greenhouses', low tunnels generally cover rows of plants in field and, therefore, they are also known as **row covers**. Clean plastic films or nets are stretched over low wire hoops (arcs up to 1.0 m high) to protect plants against frost, wind, insects and pests. The hoops are made of steel wires or bamboo strips or cane. These hoops are covered by polythene sheets of about 50 microns thickness and are provided with ventilation holes on the side opposite to the solar movement. Total surface area of such ventilation is about 4 per cent. Use of non-woven/spun-bonded fabric material, which is porous and much lighter, is a more recent trend. Low tunnels provide a passive control of plant micro climate, i.e., use of specific plastic material to control radiation and provision of natural ventilation. Plastic mulches and drip irrigation may be used in conjunction with low tunnels. There are several methods of low tunnel formation and operation. The low tunnels permit early yield for spring crops with significantly higher yields. These tunnels are not usually used for growing flowers. The crops which have been generally grown commercially under low tunnel conditions are melons, cucumber, tomato, strawberry, pepper, beans, squash and sweet corn.

Fig. 2.1: Low tunnel

A variation of the low tunnel is a plastic covered trench system where polyethylene is stretched over a trench in the ground. The trench may be 20–40 cm deep. The polyethylene is removed from the trenches when the plants start flowering to enable pollination facilitated by insects. Such trenches are showing excellent results under the cold desert conditions of Leh (Jammu and Kashmir) as moisture is also conserved to a great extent.

Advantages

1. Normally low tunnels are recommended for cultivation during winter season especially for growing early crop of cucurbits.
2. They protect crop against wind, rain, frost and snow.
3. They are suitable for raising a healthy nursery and early vegetable crops.
4. They maintain optimum temperature for plant growth.
5. They help in better nutrient uptake by the plants.

Walk-in tunnel

It is a temporary structure made by using GI pipes or bamboo, and is covered with different cladding material depending upon the season in which the cultivation is proposed. Walk-in tunnels are used for off-season cultivation of vegetables and flower seedlings. They give an advantage of better prices of the off-season produce, giving more profit per unit area. Optimum size of the walking tunnel is 60–75 sq m, with 2–2.5 m width and up to 30 m length with a 2–2.5 m central height. Overall, the height is enough for the worker to walk comfortably during operation.

Fig. 2.2: Walk-in tunnels

Advantages

1. The worker can easily walk-in to take care of the crop.
2. The cultivators get higher returns from off-season cultivation of vegetables and raising of flower seedlings.
3. These are temporary and low-cost structures, which can be fabricated by the cultivators themselves at the village level with the help of rural artisans.

Net Houses

Depending upon the cladding (covering) material used, the net houses may be classified as insect-proof net houses and shade net houses.

Insect-proof Net House

Fig. 2.3: Insect-proof Net House

An insect-proof net house can be fabricated as a temporary or permanent structure in different designs. It can be in a walk-in tunnel design and shape, with double door facility at one end of the structure. It is covered with UV-stabilised insect-proof net of 40–50 mesh for effective control of pests and diseases. The minimum size of insect-proof net house is 100 sq m. The permanent structure can be fabricated in two designs — flat roof design having 3.5–4 m height and dome shape with a height of 4.5–5 m and the other in dome shape in a popular type of greenhouse design. Usually, the quality production as well as growing seedlings are possible under these net houses with proper selection of varieties without application of harmful chemicals in their production.

Advantages

1. Off-season cultivation
2. Production of quality seedlings is possible.
3. Restrict the growth of pests and diseases.

Shade Net House

Fig. 2.4: Shade Net House

It is primarily constructed to protect plants from highly intense solar radiation. The structure is made of wood, stone, bamboo or GI pipes. When wood or bamboo are used, the poles are treated with turpentine and tar on one side before inserting them in the ground. Cladding material used on the top and sides of the structure is generally a shade net. The shade nets are available in different colours with different percentages of shade factor. Suitability of colour and shade factor is location and season-specific. Generally, shade nets are used for hardening of fruit orchard planting material raised under greenhouses.

Advantages

1. They control high intensity solar radiation.
2. They protect plants from frost.
3. They also protect plants from large insects.

Greenhouse

Fig. 2.5: Greenhouse

It is a framed or covered structure with a transparent or translucent material which permits ample sunlight for crop production and has provisions for at least partial control of plant environment.

A greenhouse, depending upon the transparency of the glazing material, admits sunlight which is absorbed by the crop, equipment, structure and the floor. These objects in turn emit thermal radiation which is only partially transmitted out of the greenhouse. As a result of this, a part of the solar energy is continually retained in the greenhouse, leading to a temperature increase. This natural temperature rise in the greenhouse is utilised during winters to grow crops with or without supplementary heat. During summers, the greenhouses are cooled as per the crop requirement.

The closed side container of the greenhouse during the night results in trapping the air rich with carbon dioxide, which would improve photosynthetic activity during the early hours of the day. Air humidity in the greenhouse can also be increased or lowered. In addition, favourable light conditions for crops, in terms of quality and quantity, can be created by providing supplementary lighting and shading systems. In general, crops in greenhouses are either grown on beds or in pots irrigated by micro-irrigation systems. Off-season vegetables, flowers and ornamental/grow-bags, plants and nursery raising are fairly remunerative practices in protected cultivation.

Advantages

1. Off-season cultivation of crops is possible round the year.
2. Crop cultivation is possible under harsh environmental conditions.

Notes

3. They provide excellent opportunities to produce export-quality crops.
4. Early production of quality seedlings and planting materials is possible.
5. More production per unit area in comparison to open field cultivation.
6. Greenhouses can also be used for growing flower plants, strawberries and propagation of quality fruit plants.
7. Insect, pest and weed management is easier in greenhouses than in open fields.
8. Greenhouses can provide substantial income for cultivators having small land holdings.

Mist Chamber

The main purpose of such a structure is to create high humidity and droplet-free presence of water for propagating delicate soft wood cuttings, vegetable crops, root plants and shrubs, etc. Cuttings are misted intermittently in place of continuous water application or drenching. The intermittent water misting is done using a high pressure pump, pipeline system and a timer switch. The mist nozzles are connected to the main pipelines for misting the plant material growing inside the growth chambers or structures. A mist chamber of 15–25 sq m is sufficient for a nursery. The frequency of misting depends upon ambient temperature and type of plant material being propagated.

Advantages

1. Assured supply of plant material throughout the year, which is not possible in open field cultivation.
2. Mist chambers reduce the rate of moisture loss from the plants, thereby helping in survival of root-cuttings as well as for hardening of tissue cultured plants. Thus, the main advantage of mist chambers is to avoid the desiccation or drying out of the plant material.
3. Planting material remains devoid of any susceptibility to pathogen, insect and pests attack.

Practical Exercises

Activity 1: Prepare a low tunnel with locally available materials.

Material required: peg, rope, measuring tape, bamboo stick/ 6 mm GI rod, insect proof net.

Procedure

1. Mark the area as per layout.
2. Insert peg as per demarcation.
3. Fix bamboo stick/GI rod.
4. Covering with cladding material.

Check Your Progress

A. Fill in the blanks

1. Low tunnel is also called as __________ greenhouse.
2. Height of low tunnel is __________ meter.
3. Polyfilm of _____________ micron thickness is used in greenhouse.
4. Centre height of walk-in tunnel is generally _________ metre.
5. Commonly used mesh size of insect-proof net house is ___________ mesh.

B. Mark the correct choice

1. Protected structures commonly used for hardening of plants is
   (a) walk-in tunnel (b) shade nethouse
   (c) greenhouse (d) low tunnel
2. Protected structures commonly used for early rooting of cuttings is
   (a) walk-in tunnel (b) shade net house
   (c) greenhouse (d) mist chamber
3. The suitable structure for propagated plant materials is
   (a) polyhouse (b) mist chamber
   (c) shade net house (d) plastic low-tunnels

C. Descriptive questions

1. Describe the types of protected structures.

____

____

____

Notes

NOTES

2. Write short notes on the following.
   (a) Low tunnel
   ____
   ____
   ____

   (b) Shade net house
   ____
   ____
   ____

   (c) Greenhouse
   ____
   ____
   ____

   (d) Mist chamber
   ____
   ____
   ____

   (e) Walk-in tunnel
   ____
   ____
   ____

D. Match the columns

A	B
1. Low tunnel cladding	a. Plants protect against solar radiation
2. Protected cultivation	b. Maintain humidity
3. Mist chamber	c. 50 micron polythene sheet
4. Shade net houses	d. Off-season cultivation

SESSION 2: CLASSIFICATION OF GREENHOUSES

Greenhouses can be classified according to the material used in their construction, the shape of their structure and the climate control methods adopted. Their classification is sometimes done on the basis of the cost of fabrication per unit area.

Classification of Greenhouses based on Cost

Low-cost Greenhouse

It is fabricated mainly using local and low-cost available material like wooden logs or bamboos. The protection of wooden structures from insects and termites is a major challenge. These structures are small in size and have a short life-span. Since the height of the structure is lesser as compared to those with steel frames, maintaining proper temperatures in summer becomes difficult. Therefore, they are recommended mostly in cold climatic zones and low wind speed regions. The approximate cost of establishing such greenhouse units ranges between Rs. 450–620 per sq m.

Fig. 2.6: Low-cost Greenhouse

Medium-cost Greenhouse

It is generally fabricated using galvanised iron (GI) square or rectangular or round pipes or lipped channel or their combinations. The whole structure is firmly fixed in the ground to withstand high speed wind up to 140 km/hr. Such greenhouses are suitable for dry and composite climatic zones. The normal height of these structures ranges between 6.5–7 m and these are mostly naturally ventilated. The climate inside the structure is regulated by opening and closing of side curtains (which are rolled above permanently fixed insect-proof net on windows). Thus, air circulation can be regulated. Humidity is maintained through operation of foggers/ misters. Light intensity can be controlled with the use of internal collapsible shading nets. The approximate cost of establishing such naturally ventilated polyhouse unit ranges between Rs. 900–1000 per sq m depending upon the size of the structure.

Fig. 2.7: Medium-cost Greenhouse

High-cost Greenhouse

For the production of sensitive, off-season, exotic or quality crops, sometimes medium-cost greenhouses cannot deliver the requisite quality. Therefore, high-cost greenhouse structures, which can precisely regulate climatic and nutritional needs of the plants,

Fig. 2.8: High-cost Greenhouse

are required. The greenhouse climate parameters are regulated through passive cooling by operating fan and pad systems and sensor-based controlled systems. The approximate cost of establishing such greenhouse units ranges between Rs. 1500–2500 per sq m depending upon the size of the structure.

Classification of Greenhouses based on shape

(a) Gothic Roof
(b) Slant Roof
(c) Saw Tooth
(d) Flat Roof

Fig. 2.9: Types of Greenhouse based on shape
(a) Gothic Roof (b) Slant Roof (c) Saw Tooth (d) Flat Roof

Classification of Greenhouses based on cladding material used

(a) Transparent glass
(b) Fiberglass reinforced plastic/polycarbonate
(c) UV-stabilised low density polyethylene film

Classification of Greenhouses based on climate control mechanisms

NOTES

Naturally Ventilated Greenhouse

The climatic parameters such as temperature, humidity, carbon dioxide in these polyhouses are maintained and/or controlled through natural air convection without using any additional systems, and are mostly operated manually.

Forced Ventilated Greenhouse

The climatic parameters such as temperature, humidity, carbon dioxide in these polyhouses are maintained and/or controlled through forced air circulation using fan and pad systems (for hot regions)/heaters (for temperate regions), foggers, curtain actuators (mechanism that makes the system work) that are controlled with automatic sensors. These systems are mostly operated automatically, however, these can be operated manually as well. These structures require continuous power supply and backup.

Factors Responsible for Selection of Specific Design of a Greenhouse

The following factors are kept into consideration while selecting a specific design.

(a) Type of crop to be grown
(b) Easy availability of raw material
(c) Local climatic conditions
(d) Investing capacity of the farmer
(e) Market demand of the produce
(f) Appreciation to the produce

Practical Exercises

Activity 1: Identify types of protected structures

Material required: pen, pencil, notebook, etc.

NOTES

Procedure

Visit any institution and note down the following information.

1. Identify types of structures.
2. Enlist kinds of material used in different structure.
3. Write down utility of each structure observed.
4. Draw sketch of protected structure.

Check Your Progress

A. Fill in the blanks

1. Climatic parameters are mainly maintained in ________.
2. In low cost naturally ventilated polyhouses ________ or _______ material are generally used.
3. In forced ventilated greenhouses the temperature inside the structure is maintained with the help of __________.
4. The normal height of medium cost greenhouses ranges between ____ and ____ m.
5. The sensor based controlled system used in _______ greenhouse.

B. Mark the correct choice

1. A greenhouse does not comes under the classification based on shape
   (a) Quonset type
   (b) Curved roof type
   (c) Gable roof type
   (d) Forced ventilated
2. An approximate cost of establishing low cost greenhouse is Rs./sq.m.
   (a) 900–1000
   (b) 1200–1500
   (c) 450–620
   (d) 200–250

C. Descriptive questions

1. Classify greenhouses on the basis of cost.

____

____

____

2. Describe in brief
   (a) Naturally ventilated greenhouse
   (b) Forced ventilated greenhouse
   (c) Criteria for selection of specific design

D. Match the columns

	A		B
1.	High cost greenhouse	a.	Manually operated
2.	Cladding material	b.	Short life span
3.	Naturally ventilated greenhouse	c.	Precisely regulated climatic
4.	Low cost greenhouse	d.	Poly ethylene film

Session 3: Major Components of a Greenhouse

A greenhouse is constructed with different material and their components. In this session, the major components used in greenhouse construction and their features and functions are described.

Different Greenhouse Components with their Features and Functions

Cladding Material

Polythenes or other transparent material used for walls and roof of a greenhouse for protection as well as transparency, which simulates climatic conditions inside the greenhouse is called cladding material. The material could be made of polycarbonate, glass or poly sheets. The polycarbonate and glass houses are temporary structures and mostly used for research or academic purposes. The polythene sheet as a cladding material is most commonly used and these films are normally UV-stabilised, 200 micron thick and fixed with aluminum profiles using zigzag springs.

It is important to select a proper film for the polyhouse, which has direct relation with the quality of the crop as well as the quantity of the produce. Polythene should be properly UV-stabilised and a minimum life span of at least three years. With 1 kg polyfilm, a maximum area of 5.4 sq m can be accommodated.

Polyhouse Film

(i) *Compulsory properties*: UV stabilisation, diffusion/ clear (light transmission)

Notes

(ii) *Optional properties*: UV blocking/antivirus, sulphur resistant, thermic, anti-drip, anti-mist, anti-dust, three-layer/five-layer films

Crop-wise Recommendations

(i) *Dutch roses*: Cladding—200 micron thick, UV-stabilised, anti-dust, anti-sulphur, with cooling effect, light diffusion

(ii) *Gerbera, Bell pepper, Anthurium and Orchids*: Cladding—200 micron thick, UV-stabilised, anti-dust, with cooling effect, light diffusion

(iii) *Carnation*: Cladding—200 micron thick, UV-stabilised, anti-dust, with cooling effect for IR protection polythene at high altitudes

Gutter

It is used for collecting rainwater from the roof of the greenhouses and are placed at an elevated level (at least 4–4.5 m from ground level) between two spans.

Gutters are made of galvanised sheet of 2 mm thickness in trapezoidal shape (preferably of single length without joint). It should be leak-proof.

Minimum of 1 per cent slope is required for the gutter. Gutter orientation is in North–South direction in multi-span greenhouse and may change according to the direction of the wind.

Foundation Pipe

It connects the structure and the ground.

Tubular Structural Members, Foundation and Labelling

These are the galvanised iron tubular/square pipe and angles. These items are used to erect a stable frame to support the cladding material and other systems in the greenhouse. These items include horizontal and vertical structure members in any polyhouse.

(i) *Purlin*: It is a member that connects cladding supporting bars to the columns.

(ii) *Ridge*: It is the highest horizontal section on top of the roof.

Indian Standards for construction of Greenhouse/Polyhouse

The Bureau of Indian Standards (BIS) has formulated following standards with respect to Polyhouse/Greenhouses.

1. IS 14462:1997: Recommendation for layout, design and construction of greenhouse.
2. IS 14485:1998: Recommendations for heating, ventilating and cooling of greenhouse.
3. IS 15827:2009: Plastics films for Greenhouse

(iii) *Girder*: It is a horizontal structural member, connecting columns on gutter height.

(iv) *Bracings*: These support the structures against wind.

(v) *Arches*: These support covering or cladding materials.

Polyhouse Length and Width, Orientation

gable: transparent wall of a greenhouse

(i) Polyhouse length is the dimension of the polyhouse in the direction of gable. (Length is side along the gable or side along the truss lines)

(ii) Polyhouse width is the dimension of the polyhouse along the gutter.

(iii) Orientation of polyhouse for single-span structures, should be East–West. For multi-span structures, the orientation should be North–South. The distance of trees adjacent to the greenhouse should be about 2.5 times the height of the greenhouse, to avoid shade.

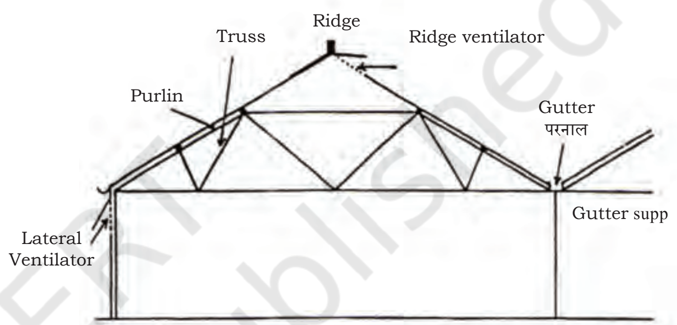
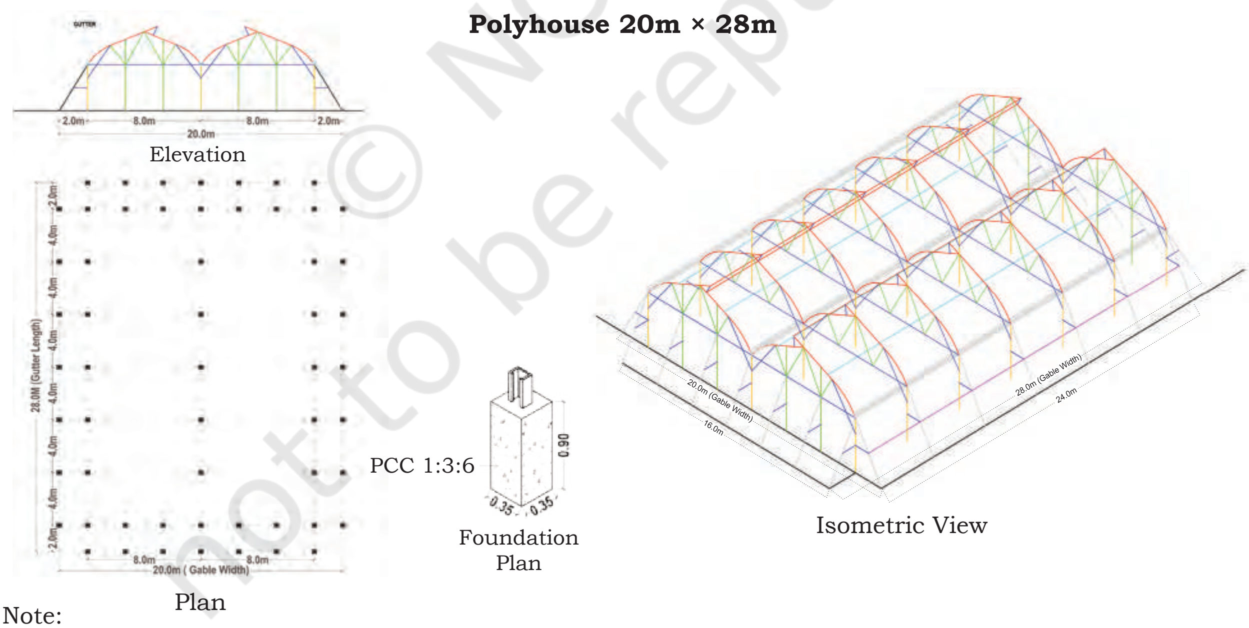


Fig. 2.10

Polyhouse 20m × 28m



Note:
Gable Width–20m
Gable Length–28m
The Greenhouse measurements are measured by Gable dimension as a Width and Gutter side dimension as a Length (As shown in Drawing)

NOTES

Micro Irrigation System

Micro irrigation system is the best way for watering plants in a polyhouse as per the daily needs and the stage of the crop. Besides this, care should be taken that water does not trickle directly on the leaves or the flower, which may lead to disease and scorching of leaves or flowers.

Fertigation Equipment

For providing fertilisers to the plants as per their daily needs, water-soluble or liquid fertilisers are injected in the irrigation mainlines feeding the greenhouse crops. Fertiliser dosers and tanks are used for injecting soluble fertilisers. They can also be connected to automatic mixing and dispensing unit. The fertilisers are dissolved in different tanks as per compatibility and are mixed in discrete proportions for supply to the plants through drip irrigation systems.

Spraying System

This system is used for spraying required chemicals on the crop to control pests and diseases, if any. The spraying machines are normally portable but may be equipped with high pressure motorised piston pumps and nozzles.

Exhaust Fan and Cooling Pads

For removing hot air from the greenhouses in forced ventilated greenhouses, cooling pads are used for cooling the air entering into the greenhouses.

These systems are operated as and when the climatic parameters like temperature, humidity, etc., inside the greenhouse need manipulation as per crop growth requirement.

Shading Net

These are used for controlling light intensity falling on the crops inside the greenhouse. Various shading nets with shading capacities like 35 per cent, 50 per cent, 75 per cent are used for different crops and seasons.

Sensors and Controllers

They are used for controlling climatic parameters automatically inside hi-tech greenhouses. These systems are generally used for very high-value crops and sensitive activities like soil-less cultivation, tissue culture plant and hardening activities.

Notes

Practical Exercises

Activity 1: Enlist the different components of a greenhouse structure

Materials required: notebook, pen, etc.

Procedure

- Visit the nearby greenhouse.
- Observe different components of the greenhouse.
- Note down the components and their use.
- Draw figures of different components.

Check Your Progress

A. Fill in the blanks

1. Transparent material mounted on the walls and roof of a greenhouse is known as ______________.
2. Gutters are used for __________ the rain water from the roof of greenhouse.
3. In polyhouse _____________ polyfilm as cladding material is generally used.

B. Multiple choice questions

1. The distance of trees near to the greenhouse should be about ____ times the height of the greenhouse
   (a) 1.5 (b) 2.5
   (c) 3.5 (d) 4.5
2. One kilogram weight of polyfilm can be accommodated in ____________.
   (a) 5.4 sq. (b) 3.4 sq.
   (c) 2.4 sq. (d) 1.4 sq.

C. Descriptive questions

1. What are the different components of the greenhouse?

____

____

____

NOTES

2. Write short notes on
    (i) Shading net
    (ii) Micro irrigation system
    (iii) Fertigation equipment

D. Match the columns

A	B
1. Connects cladding supporting bars to columns	(a) Foundation pipe
2. Highest horizontal section in top of the roof	(b) Purlin
3. To support the structure against wind	(c) Ridge
4. Connection between the structure and ground	(d) Bracings

Floriculturist (Protected Cultivation)-Class 11- Unit 2 Session 1

A. Fill in the blanks

1. Low tunnel is also called as __________ greenhouse.
2. Height of low tunnel is __________ meter.
3. Polyfilm of ____________ micron thickness is used in greenhouse.
4. Centre height of walk-in tunnel is generally _________ metre.
5. Commonly used mesh size of insect-proof net house is __________ mesh.

B. Mark the correct choice

1. Protected structures commonly used for hardening of plants is
   (a) walk-in tunnel (b) shade nethouse
   (c) greenhouse (d) low tunnel
2. Protected structures commonly used for early rooting of cuttings is
   (a) walk-in tunnel (b) shade net house
   (c) greenhouse (d) mist chamber
3. The suitable structure for propagated plant materials is
   (a) polyhouse (b) mist chamber
   (c) shade net house (d) plastic low-tunnels

C. Descriptive questions

1. Describe the types of protected structures.

____

____

____

2. Write short notes on the following.

(a) Low tunnel

____

____

____

(b) Shade net house

____

____

____

(c) Greenhouse

____

____

____

(d) Mist chamber

____

____

____

(e) Walk-in tunnel

____

____

____

D. Match the columns

A	B
1. Low tunnel cladding	a. Plants protect against solar radiation
2. Protected cultivation	b. Maintain humidity
3. Mist chamber	c. 50 micron polythene sheet
4. Shade net houses	d. Off-season cultivation

Floriculturist (Protected Cultivation)-Class 11- Unit 2 Session 2

A. Fill in the blanks

1. Climatic parameters are mainly maintained in ________.
2. In low cost naturally ventilated polyhouses ________ or _______ material are generally used.
3. In forced ventilated greenhouses the temperature inside the structure is maintained with the help of _________.
4. The normal height of medium cost greenhouses ranges between ____ and ____ m.
5. The sensor based controlled system used in _______ greenhouse.

B. Mark the correct choice

1. A greenhouse does not comes under the classification based on shape
   (a) Quonset type
   (b) Curved roof type
   (c) Gable roof type
   (d) Forced ventilated
2. An approximate cost of establishing low cost greenhouse is Rs./sq.m.
   (a) 900–1000
   (b) 1200–1500
   (c) 450–620
   (d) 200–250

C. Descriptive questions

1. Classify greenhouses on the basis of cost.

____

____

____

2. Describe in brief
   (a) Naturally ventilated greenhouse
   (b) Forced ventilated greenhouse
   (c) Criteria for selection of specific design

D. Match the columns

A	B
1. High cost greenhouse	a. Manually operated
2. Cladding material	b. Short life span
3. Naturally ventilated greenhouse	c. Precisely regulated climatic
4. Low cost greenhouse	d. Poly ethylene film

Floriculturist (Protected Cultivation)-Class 11- Unit 2 Session 3

A. Fill in the blanks

1. Transparent material mounted on the walls and roof of a greenhouse is known as ____________.
2. Gutters are used for _________ the rain water from the roof of greenhouse.
3. In polyhouse ____________ polyfilm as cladding material is generally used.

B. Multiple choice questions

1. The distance of trees near to the greenhouse should be about ____ times the height of the greenhouse
   (a) 1.5 (b) 2.5
   (c) 3.5 (d) 4.5
2. One kilogram weight of polyfilm can be accommodated in ___________.
   (a) 5.4 sq. (b) 3.4 sq.
   (c) 2.4 sq. (d) 1.4 sq.

C. Descriptive questions

1. What are the different components of the greenhouse?
   ____
   ____
   ____
2. Write short notes on
   (i) Shading net
   (ii) Micro irrigation system
   (iii) Fertigation equipment

D. Match the columns

A	B
1. Connects cladding supporting bars to columns	(a) Foundation pipe
2. Highest horizontal section in top of the roof	(b) Purlin
3. To support the structure against wind	(c) Ridge
4. Connection between the structure and ground	(d) Bracings

Unit 3

Preparation of Media and Container for Commercial Cultivation in Greenhouses

171111CH03

Introduction

The production of greenhouse crops involves a number of agricultural inputs. Among these, growing media or substrate or soil is one of the most critical components. Growing media comprise material aimed to provide ideal physical and chemical characteristics for the root environment. In greenhouse agriculture, a good substrate has proper structural characteristics to support optimum irrigation, maintain proper moisture and aeration, development of roots, adapt to fluctuations in temperature, pH and EC as the plant grows. Various types of growing media used in protected cultivation include peat moss, vermiculite, perlite, shredded coconut husks (coco peat), or composted materials plus starter nutrients and a wetting agent. These media can also be combined in desired proportions as a recipe or formulation as per requirement of the crop or situation. These are used because soils from the field are often vulnerable to diseases and pests and may not provide healthy growth of plants particularly in containers. Besides, these media in right proportions can provide aeration, drainage, water-holding capacity and nutrient uptake by the plant while also resisting the development of diseases or germination of weeds.

Session 1: Growing Media and its Composition

Growing Media

The material in which plants grow in pots are known as the potting material. Substrate or the medium which is used to grow plants is commonly called the growing medium. Media is a source of mineral nutrients, moisture and support for the plant.

- *Mineral source*: Media supplies the necessary nutrients for plant growth.
- *Moisture source*: Media also supplies the necessary water for the plant.
- *Plant support*: The third major function of the media is to afford mechanical support for the plant and its roots, while also ensuring optimum moisture and aeration for roots.

Different Types of Growing Media

Fig. 3.1: Soil as a Growing Media

In most cases, two types of growing media are used in protected cultivation *viz*. soil and soilless media.

Soil as a Growing Medium

Soil is the basic natural medium for growing plants and is indeed the cheapest source. Loamy and porous soil, rich in organic matter with neutral pH (around 7) is good for the growth of plants. Soil is mixed with sand and farmyard manure (2:1:1) for better aeration, water-holding capacity and nutrient supply to the plants.

Problems of soil as a medium

(i) It is difficult to maintain the nutritive status, pH and water-holding capacity of soil as per the requirements of a particular crop for long duration.

(ii) The soil-borne pathogens pose a serious threat to the plants, resulting in lower production.

(iii) Some types of soil such as saline or ill-drained soil create problems in soil aeration, porosity, nutrient uptake, etc., which in turn affect the crop productivity.

Soilless Substrates as Growing Media

(a) In recent years, due to the problems of using soil as a growing media, the media other than soil (solid or liquid) are used as a base to grow plants under protected conditions. This is called 'soilless culture'.

Fig. 3.2: Soilless substrates as a growing media

Advantages of Soilless Culture

(i) Soilless culture media, whether liquid or solid, facilitates precise nutritional requirement of the plant.
(ii) It helps pathogen-free cultivation.
(iii) More economical use of fertiliser is possible.
(iv) Labour saving in weeding and fertiliser applications.
(v) Saving basal doses of manure.
(vi) Crop cultivation under problematic soil conditions is possible.

Different Media or Substrates

Coco peat

Fig. 3.3: Coco peat

It is a byproduct of the coconut industry, and is used widely as a substrate due to its low cost, aeration, drainage and long life. It is supplied in loose form as well as in compressed brick forms. The compressed bricks are easy to transport at low costs. The bricks weigh about 4–5 kg and can expand to 4–5 times of their volume once water is added after loosening them. It is advisable to use coco peat after treatment with steam or other means of disinfestation.

Fig. 3.4: Vermiculite

Vermiculite

It is an aluminum–iron–magnesium silicate. It is a mica-like mineral which expands to open-flake structures on heating at high temperatures. Vermiculite is available in various grades and particle sizes and can have a bearing on the choice, depending upon the size of nursery pots. The finer grades are used for small pots and nursery trays, while large or coarse grades may be used in large containers. Vermiculite has a range of pore spaces, which can retain considerable amount of moisture on wetting. It also contains important minerals, especially calcium and magnesium besides having a near neutral pH. Vermiculite is a critical desirable component of soilless root substrates because of its high nutrient and water retention and good aeration capacity while bearing a low bulk density.

Fig. 3.5: Perlite

Perlite

It is a crushed volcanic rock that has been heated and expanded to become a lightweight, white material. Perlite is sterile and has a neutral pH. It improves air space and water drainage of the nursery medium. It is a hard material that does not break apart easily. It can hold about 3–4 times of water equal to its weight in water. Use of perlite keeps the weight of the media lesser in comparison to soil.

Fig. 3.6: Rock wool

Rock wool

It is a burnt mixture of coke, basalt, limestone and also the slag from iron production. It is ground to produce a fine powdered or granular form. This powdered form used in the media provides good aeration and water-holding capacity. It is slightly alkaline; it neither contributes nor holds nutrients to any extent, therefore it is mixed with other growing media such as sphagnum peat moss.

Sand

It is the basic component of soil. Its particle size ranges from 0.05 mm–2.0 mm in diameter. It improves aeration and drainage and needs minimum cost incurrence. While sand is vulnerable to diseases and pests, however once sterilised, it can prove to be a good medium for both potting and propagation media.

Rice Husk

It is a byproduct of the rice milling industry. It is extremely light in weight and is very effective for improving drainage.

Bark

It is a byproduct of saw mills, which is used as a media for pot cultures as well as in greenhouses. It provides aeration at low cost. It is either used alone in containers or mixed with one-fourth part of peat moss for improving water-holding capacity. Bark particles of less than 3/8 inch (9.5 mm) in size are used as growing media in general. Bark has low nutrients and very low pH (3.5–6.5) when used unprocessed. For improving the pH of the bark medium, dolomite lime may be added to bring it above a pH of 6 at the least.

Sphagnum Peat moss

It is also called peat moss or simply peat. Peat is the most popular component of most soilless substrate media or mixes used as soilless medium because of its lower cost and easy availability. It originates from the partial decomposition of plant material in peat bogs where oxygen availability is low. All the peats have very favourable water-holding capacity, high Cation Exchange Capacity (CEC), low nutrient contents, low pH (around 3 to 4.5) and requires limestone addition to balance the pH.

Fig. 3.7: Sphagnum Peat moss

Saw dust

It is similar to peat moss in many ways and its quality depends on the type of trees. It may contain toxic substances such as resins, tannins or turpentine. It is acidic in nature and requires limestone to neutralise it.

Composition of Media

Many substrates are available that can be used singly or in combination by mixing in definite proportions, depending upon the crop requirements such as plant

Notes

support, aeration, nutrient and moisture retention. The selection of components generally depends on their availability and cost.

Standard soilless composition includes composite mixture of coco peat, vermiculite and perlite in 3:1:1 volume by volume ratio.

In case of seedling nursery, coco peat alone may be used as a growing media after treating it with calcium nitrate (50 g/kg) to reduce the electrical conductivity and pH of the media.

If timber is available in abundance, use of bark as a growing medium is economical. Sand is added to bark because it settles in spaces and nests among the bark particles, thus adding more surface area and as a consequence, more air and water are available in a given volume of substrate. Often, sphagnum peat moss is also added to the bark to further increase water-holding capacity as well as nutrient retention.

Practical Exercises

Activity 1: Prepare a soilless growing medium.

Materials required: coco peat, vermiculite, perlite, pot, etc.

Procedure

- Identify different components of soilless media.
- Measure the quantity of components used.
- Prepare composite mixture of coco peat, vermiculite, perlite in 3:1:1 volume by volume ratio.
- Fill the pot with prepare media.

Ckeck Your Progress

A. Fill in the blanks

1. The growing medium which is prepared from coconut fiber is known as ____________.
2. Growing media which is obtained from volcanic rock is known as __________.
3. Vermiculite contains important minerals such as _________ and ______.
4. The standard soilless composition ratio of coco peat, vermiculite and perlite is ________.

B. Multiple choice questions

1. Substrate which is used to grow plants is commonly called the ___________.
   (a) bark
   (b) rock wool
   (c) growing medium
   (d) vermiculite
2. Which is not used as soilless media?
   (a) Vermiculite
   (b) Perlite
   (c) Coco peat
   (d) Vermiwash
3. Sand as growing medium improves the ___________.
   (a) aeration and drainage
   (b) water-holding capacity
   (c) nutritive status
   (d) pH
4. Growing media is a source of ___________.
   (a) mineral nutrients
   (b) moisture
   (c) support to plant
   (d) All of these

C. Descriptive questions

1. Describe different types of growing media.

____

____

____

2. Describe in brief
   (a) Problems of soil as a medium
   (b) Sphagnum peat moss
   (c) Coco peat

____

____

____

D. Match the columns

	A		**B**
1.	Perlite	(a)	Neutral base fibre
2.	Vermiculite	(b)	Milling industry
3.	Coco peat	(c)	Light, white, substrate
4.	Rice husk	(d)	Mica-like mineral

Notes

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SESSION 2: STERILISATION OF GROWING MEDIA

Sterilisation can be defined as the process of removal or destruction of all forms of microbial life. Any sterile item in the microbiological sense actually has to be free of any living micro-organisms. Micro-organisms can be killed, inhibited or removed by exposing material to lethal agents which may be physical, chemical or ionic in nature or in the case of liquids, physical elimination of cells from the medium.

Soil Sterilisation

The soil or soilless media are used for growing the plants, supporting the plant, retaining the moisture and providing water and nutrients for the root system. The media used for cultivation of plants are also often congenial for the growth of micro-organisms *viz*. bacteria, fungi, actinomycetes, protozoa, viruses, insects, nematodes and weed seeds. The micro-organisms include beneficial as well as harmful, i.e., soil-borne plant disease causing organisms. To eliminate soil-borne pathogens, nematodes, insects and weeds to obtain healthy growth of plants, it is essential to sterilise or pasteurise the soil or soilless media.

Methods of Soil Disinfestation

A variety of techniques and agents are available for soil disinfestation. They act in many different ways and each has its own limits of application. The selection of a method depends upon the desired efficiency, its applicability, toxicity, availability and cost and effect on the properties of the object to be disinfested.

Among the variety of physical and chemical agents and techniques available, the more commonly used for soil or substrate sterilisation are moist heat, i.e., steam sterilisation and chemicals, i.e., fumigants.

Soil Solarisation

High intensity solar radiation during summer (April–June) is used as a lethal agent for the control of plant pathogenic organisms, insects, nematodes and weeds through the use of transparent polyethylene films and this is known as soil solarisation. The step-by-step procedure of soil solarisation includes—

(i) Soil should be ploughed first.
(ii) Irrigate the field very ligthly.
(iii) Cover the field with transparent UV-stabilised 25 micron polyfilm for 20–30 days.
(iv) The sides of the film should be covered with soil to avoid entry of outside air.
(v) Soil solarisation is not a foolproof method for sterilisation.

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Soil Sterilisation by Formaldehyde

It is an excellent sterlising agent for controlling harmful soil microbes. It is marketed in aqueous solution as formalin which contains 37–40 per cent formaldehyde. The soil or root substrate to be sterilised is loosened and the solution prepared by mixing 4 L formalin in 19 L of water is poured or sprayed on the soil @5 ml/ sq m area. The rate of application depends upon the moisture content, depth of soil and type of soil. The land is covered with thin plastic film to retain the fumes generated. Removal of plastic film (after 7 days), complete evaporation of smell of formaldehyde will take place in about 15–20 days. After that, sowing or planting should be done. It has limited effect against nematodes and should not be used in standing crops. Its use has to be preferably avoided as it is a general biocide (a substance that destroys or inhibits the growth or activity of living organisms), deteremental to the health and safety of the production system.

Soil Sterilisation by Hydrogen Peroxide

Hydrogen peroxide with nano particle silver can be used for sterilisation. Since this solution is in liquid form, it can be applied using drip irrigation system. The recommended dose of the solution is 35–40 ml/ sq m, however care should be taken that the soil beds are gently watered beforehand. The main advantage of using this solution is that sowing/planting can be done the very next day.

Other sterilisation methods include heat or steam sterilisation, which have limitation of application under field conditions due to high expenditure.

Notes

Practical Exercises

Activity 1: Demonstrate procedure of soil solarisation.

Material required: polyfilm of 25–50 micron, water can, *'Khurpi'*, etc.

Procedure

- Open the soil surface with *Khurpi* and prepare a bed of 2.5 m × 2.5 m size.
- Irrigate the bed lightly.
- Place the polyfilm on the top of the area and cover the edges with soil.
- Leave it for 20–30 days.
- Observe germination of weeds.

Check Your Progress

A. Fill in the blanks

1. A high intensity solar radiation used for treating soil is known as ___________.
2. An excellent sterlising chemical for controlling soil microbes is ________________.
3. The recommended dose of hydrogen peroxide when used for sterilisation is _______ ml per sq m.

B. Mark the correct choice

1. For soil solarisation use UV stabilised transparent sheet of _________ micron
   (a) 25 (b) 35
   (c) 45 (d) 55
2. Physical method of soil disinfection by _________.
   (a) weedicide (b) fungicide
   (c) solarisation (d) formaldehyde

C. Descriptive questions

1. What is soil sterilisation? Describe the method of soil solarisation.

2. Describe the soil sterlisation by formaldehyde.

D. Match the columns

A	**B**
1. Soil Sterilisation	(a) Micro-organsim
2. Aseptic	(b) Fumigent
3. Bacteria	(c) Microbe-free
4. Formadehyde	(d) Peak Summer

Session 3: Preparation of Beds and Containers for Growing Crops

Preparation of Raised Beds

Fig. 3.8: Land preparation under polyhouse

Bed preparation in a greenhouse, polyhouse, net house or a tunnel is very important and it plays a crucial role while growing plants. First of all, it is important to select 'well drained' soil for growing plants (like loam, red soil). If it is not available, then the soil should be improved by adding rice husk, compost (dry), etc., so that it becomes well-drained. The required composition for 4,000 sq m of land area is—Farm Yard Manure (FYM) 3 truck, rice husk 2 MT, neemcake1 MT, and fish meal/bonemeal 0.25 MT. Once it is mixed thoroughly, fumigation is done with hydrogen peroxide, after which the soil is kept closed for at least 24 hours and then the layout of beds is marked as per requirement. Pegs are used to fix lines before starting the bed preparation. The height of the bed should be equal, about 30–45 cm from the ground, with a width of 75–90 cm. The width of the path between two beds should be 50 cm. These beds are good for better aeration and drainage and are more common in greenhouse cultivation.

For crops other than flowers, cultivators prepare planting beds differently.

Plant Growing Containers for Greenhouse Production

The duration of a crop in the greenhouse is the key to make the greenhouse technology profitable. Therefore, the use of containers in greenhouse production carries significance.

They are used for the following important activities in greenhouse production.

Fig. 3.9: Plant growing in different types of containers

(i) Raising of seedlings in the nursery.
(ii) Growing plants in greenhouses for hybrid seed production of flowers.
(iii) Growing cut flowers in greenhouses.
(iv) Growing potted ornamental plants in greenhouses.

Advantages of Containers in Greenhouse Production

(i) Increase in production capacity by reducing crop duration.
(ii) Quality production of nursery or crop.
(iii) Uniformity of plant growth, and better vigour and survival rates.
(iv) Provide quick take-off with little or no transplanting shock.
(v) Easy maintenance of sanitation in greenhouse.
(vi) Easy to handle, grade and shift for transportation.
(vii) Better water drainage and aeration in pot media.
(viii) Easy to monitor chemical characteristics and plant nutrition with advanced irrigation system like drip irrigation.
(ix) Protection from soil-borne pathogens.

Table 3.1: Advantages and Disadvantages of plant growing in containers

Containers	Advantages	Disadvantages
Polyurethane foam	• Requires less medium • Reusable • Easy to handle	• Requires regular fertilisation
Pro-trays	• Easy to handle • Reusable	• May be limited in sizes
Polyethylene bag	• Easy to handle	• Requires less storage space
Plastic pot	• Reusable, Good root penetration	• Requires handling as single plant
Plastic tray	• Available in many sizes • Reusable • Requires less medium	• Roots may grow out of the container
Clay pot	• Easy water management • Low cost	• They are heavy to handle, uses due to easy breakage. • Slow to work with pots and dry out fast

Single peat pot	• Easy to handle in field • Available in variable sizes (square/round) • Good root penetration	• Difficult to separate
Plastic bag	• Easy to handle	• Roots may grow out of container

Selection of suitable containers depends on the crop to be produced in the greenhouse, plant characteristics like crop stage, duration, vigour, growth habit, root system, etc. Generally, small containers are suitable for nursery and small plants or short plants with less growth of roots, while large containers are used for plants with profuse root system.

Practical Exercises

Activity 1: Prepare a raised bed

Material required: spade, measuring tape, pegs and rope, etc.

Procedure

- Measure the area of desired size.
- Insert the pegs as per identified area and encircle it with rope.
- With the help of spade loosen the soil.
- Lift the soil from the channels and put it on beds.
- Measure the width, height of the beds.

Check Your Progress

A. Fill in the blanks

1. The low cost container for growing plants is ___________.
2. Easy to handle and reusable containers are _________.

B. Mark the correct answer

1. While preparing nursery bed, path width should be left between two beds
   (a) 30 cm (b) 40 cm
   (c) 50 cm (d) 60 cm
2. The large containers are used for plants with
   (a) small roots (b) medium roots
   (c) primary roots (d) profuse roots

NOTES

Notes

C. Descriptive questions

1. Explain in brief the preparation of raised beds.

___

___

___

2. What are the advantages of using containers?

___

___

___

3. What are the types of containers needed for deep rooted crops?

___

___

___

D. Match the columns

	A		B
1.	Raised bed	(a)	Earthen pot
2.	Sterilisation	(b)	Plastic nursery tray
3.	Pro-trays	(c)	Making aseptic
4.	Clay pot	(d)	30–45 cm height

Floriculturist (Protected Cultivation)-Class 11- Unit 3 Session 1

A. Fill in the blanks

1. The growing medium which is prepared from coconut fiber is known as ___________.
2. Growing media which is obtained from volcanic rock is known as _________.
3. Vermiculite contains important minerals such as ________ and _____.
4. The standard soilless composition ratio of coco peat, vermiculite and perlite is _______.

B. Multiple choice questions

1. Substrate which is used to grow plants is commonly called the __________.
   (a) bark
   (b) rock wool
   (c) growing medium
   (d) vermiculite
2. Which is not used as soilless media?
   (a) Vermiculite
   (b) Perlite
   (c) Coco peat
   (d) Vermiwash
3. Sand as growing medium improves the __________.
   (a) aeration and drainage
   (b) water-holding capacity
   (c) nutritive status
   (d) pH
4. Growing media is a source of __________.
   (a) mineral nutrients
   (b) moisture
   (c) support to plant
   (d) All of these

C. Descriptive questions

1. Describe different types of growing media.

   ____

   ____

   ____

2. Describe in brief
   (a) Problems of soil as a medium
   (b) Sphagnum peat moss
   (c) Coco peat

   ____

   ____

   ____

D. Match the columns

A	B
1. Perlite	(a) Neutral base fibre
2. Vermiculite	(b) Milling industry
3. Coco peat	(c) Light, white, substrate
4. Rice husk	(d) Mica-like mineral

Floriculturist (Protected Cultivation)-Class 11- Unit 3 Session 2

A. Fill in the blanks

1. A high intensity solar radiation used for treating soil is known as __________.
2. An excellent sterlising chemical for controlling soil microbes is ______________.
3. The recommended dose of hydrogen peroxide when used for sterilisation is ______ ml per sq m.

B. Mark the correct choice

1. For soil solarisation use UV stabilised transparent sheet of ________ micron
   (a) 25 (b) 35
   (c) 45 (d) 55
2. Physical method of soil disinfection by ________.
   (a) weedicide (b) fungicide
   (c) solarisation (d) formaldehyde

C. Descriptive questions

1. What is soil sterilisation? Describe the method of soil solarisation.

____

____

____

2. Describe the soil sterlisation by formaldehyde.

____

____

____

D. Match the columns

A	B
1. Soil Sterilisation	(a) Micro-organsim
2. Aseptic	(b) Fumigent
3. Bacteria	(c) Microbe-free
4. Formadehyde	(d) Peak Summer

Floriculturist (Protected Cultivation)-Class 11- Unit 3 Session 3

A. Fill in the blanks

1. The low cost container for growing plants is __________.
2. Easy to handle and reusable containers are ________.

B. Mark the correct answer

1. While preparing nursery bed, path width should be left between two beds
   (a) 30 cm (b) 40 cm
   (c) 50 cm (d) 60 cm
2. The large containers are used for plants with
   (a) small roots (b) medium roots
   (c) primary roots (d) profuse roots

C. Descriptive questions

1. Explain in brief the preparation of raised beds.

____
____
____

2. What are the advantages of using containers?

____
____
____

3. What are the types of containers needed for deep rooted crops?

____
____
____

D. Match the columns

	A	B
1.	Raised bed	(a) Earthen pot
2.	Sterilisation	(b) Plastic nursery tray
3.	Pro-trays	(c) Making aseptic
4.	Clay pot	(d) 30–45 cm height

Unit 4

Irrigation and Fertigation in Greenhouses

Introduction

An efficient irrigation system, preferably micro irrigation, combined with fertigation system is required for any type of greenhouse cultivation. The quality of water is an important parameter to be considered when micro irrigation systems are used. Poor quality water may clog the emitting points of micro irrigation systems. In micro irrigation systems, less quantity of water is used precisely to meet the crop water requirement. In this Unit, quality and the quantity of irrigation water required, the types of micro irrigation systems, types of fertiliser and fertigation methods are discussed with reference to flower cultivation under greenhouses. Besides, processes for cleaning and maintenance of fertigation equipment have also been discussed.

Session 1: Micro Irrigation Systems and their Application

Quality and Quantity of Water required for Irrigation in Greenhouse

Water quality can be defined as the quality that influences its suitability for specific use, i.e., whether the quality is suitable for drinking, irrigation, industrial

EC: the electrical conductivity of water estimates the total amount of solids dissolved in water, i.e., TDS, which stands for Total Dissolved Solids. TDS is measured in ppm (parts per million) or in mg/l.

pH: it is a measure of how acidic or basic water is. The range goes from 0–14, with 7 being neutral. A pH of less than 7 indicates acidity, whereas a pH greater than 7 indicates a basicity. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water.

use, etc. For successful flower crop production in a greenhouse, attention must be given to the quality of water. Drip fertigation requires good quality water, i.e., it should be free of suspended particulates, solids or micro-organisms that can possibly choke small openings (orifices) of the emitters. For cultivation of flowers in a controlled environment, water quality plays a pivotal role in the production of cut flowers for its colour, stem length and bud size along with climatic conditions. Normally, a pH between 6.5–7 is recommended for irrigation, and electrical conductivity (EC) should be less than 0.7ds/m. In such a case, after addition of fertilisers, the pH goes up, EC goes more than 1 ds/m and we have to maintain the uptake of fertilisers.

Generally, the requirement of water is based on the following factors.

(i) Plant spacing
(ii) Canopy (covering) area
(iii) Rate of evaporation and transpiration
(iv) Soil type
(v) Age of plants (growth stage) and fertiliser requirement
(vi) Stage of plants: vegetative growth and harvesting stage
(vii) Season

Table 4.1: The general quality of irrigation water and water requirement for flower cultivation

S. No.	Description	Rose	Gerbera	Carnation
1.	Number of plants per sq m	6	6	20
2.	Spacing	30 × 37.5 cm	30 × 37.5 cm	15 × 15 cm
3.	Water pH	6.5–7.0	6.5–7.0	6.5–7.0
4.	Electrical Conductivity (EC)	<0.7	<0.7	<0.7
5.	Life-cycle	50–60 months	30–36 months	24 months
6.	Water requirement per day	3–4 litres sq m/day	3–4 litres sq m/day	3–5 litres sq m/day

Depending upon the peak water requirement of the plant and the number of plants, a storage tank or source of the desired capacity is made available for proper irrigation.

Micro Irrigation Systems and their Application

The selection of irrigation systems with a fertigation arrangement is important for protected cultivation. The selection of drip system depends on the following factors.

(i) Crop spacing
(ii) Crop water requirement
(iii) Soil type
(iv) Growing media
(v) Where to grow: beds/trough/pots
(vi) Discharge rate of emitter
(vii) Distances of emitters on drip line
(viii) Bed size
(ix) Water quality
(x) Electricity availability
(xi) Fertigation requirements of crop

Benefits of Drip System

(i) More efficient water use.
(ii) More efficient use of fertilisers.
(iii) Less pumping cost.
(iv) Less chemical usage.
(v) Less labour required.
(vi) Significantly higher yield.
(vii) Better crop quality.
(viii) Better uniformity of application.

Fig. 4.1: Drip Irrigation System

The drip system should be easily serviceable, economical, user-friendly with higher emission uniformity and lower coefficient of variation, to maintain optimum moisture level in the soil. For different crops, different discharge and spacing options available in the market can be used. The diameters of laterals depend on the total discharge in specific length and frictional loss. Though there are different diameters available in the market, the most common are 12 mm and 16 mm. The discharge for closed spacing crop should be lower, like for carnation: 1 litre per hour (LPH)/2 LPH @ 20 cm spacing. Generally, for rose and gerbera, a 16 mm diameter 2 LPH @ 20 cm/30 cm spacing inline drippers are used. For potted plants, stake drippers of 1 LPH for each pot are used.

There are various type of drip systems available in the market based on land topography and usage. These systems are used for performing the following functions.

(i) Non Pressure Compensating (NPC)
(ii) Pressure Compensating (PC)
(iii) Pressure Compensating cum Non-Leaking (PCCNL)/ Pressure Compensating with Anti-leak

Fig. 4.2: Accessories of drip line
(1) Start connecter
(2) Rubber grommet
(3) Lateral control valve
(4) Lateral end plug
(5) End Cap
(6) Start connecter
(7) Tee
(8) Elbow
9) Mini sprinkler

Fig. 4.3: NPC Dripper

Fig. 4.4: PC Dripper

Fig. 4.5: PCCNL Dripper

Fig. 4.6: PCCNL Dripper with Stake

Sprinkler System

This system is more popular for nurseries like seedling units where the spacing remains very close, plants are too small and density is very high. Nowadays, overhead, anti-leak sprinklers (hanging like foggers) are more popular in India because they have several advantages as being overhead it facilitates better working space. Moreover, since it is anti-leak, cyclic use and greater uniformity of application is possible.

Also, nowadays people are using sprinklers at the roof of greenhouse/polyhouse because due to dust formation at roof, the transparency of light remains lower and it helps to clean the roof. Please note that this operation should be done at night so that during sunshine, the film remains dry, otherwise there may be algae formation.

Fig. 4.7: Water sprinkler

Practical Exercises

Activity 1: Identify components of drip irrigation system.

Material required: notebook, pen, etc.

Procedure

- Visit a drip irrigation unit
- Observe the types of drip system
- Note down the different components of the unit
- Identify different types of valves, drippers, lateral, etc
- Write the functions of different components

Activity 2: Visit a greenhouse and note down plant spacing of different flower plants.

Material required: pen, pad, measuring tape, etc.

Procedure

- Note down the flower crop grown in protected structure.
- Observe the flower plantation/spacing.
- Measure at three different places and take average of plant-to-plant and row-to-row distance.
- Calculate the total number of plants per sq. metre and total number of plants in protected structure.

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Check Your Progress

A. Fill in the blanks

1. Commonly available diameter of laterals in India is __________ and _________ mm.
2. For potted plants stake drippers of discharge ______ LPH for each pot is used.
3. Sprinklers used on the top of greenhouse helps in ______________.
4. Normally pH of irrigation water should range between ______________.
5. Normally, in greenhouse the number of carnation plants per sq m is ___________.
6. Water requirement of rose plants is ______________ per sq m/day.

B. Mark the correct answers

1. A method of irrigation in which use of less water precisely to the crop is ___________.
   (a) Flood irrigation
   (b) Macro irrigation
   (c) Basin irrigation
   (d) Micro irrigation
2. Which of the following can adjust pressure but not control leakage?
   (a) NPC dripper
   (b) PC dripper
   (c) PCCNL dripper
   (d) None of these

C. Descriptive questions

1. What is quality of water?

____

____

____

2. What is drip irrigation system? Write some of its benefits.

____

____

____

3. Write in brief
   1. Micro irrigation system and its application
   2. Sprinkler system

D. Match the columns

	A		B
1.	Drip irrigation	(a)	Nozzles and dripper
2.	Emitters	(b)	pH and EC
3.	Water quality	(c)	Trickle irrigation
4.	Sprinkler	(d)	Water let out

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Session 2: Types of Fertilisers and their Scheduling

Most greenhouse operations apply soluble fertilisers through irrigation systems, thus the use of the term 'fertigation'. This is accomplished by drip (pipes) where soluble fertilisers are injected using injectors at a calculated quantity of concentrated solution (stock solution) into the irrigation line so that the water from the hose (dilute solution) carries as much fertiliser as planned. Fertigation provides not only greater resource optimisation, but also better adaptability for suitable placement and delivery of inputs, thereby increasing nutrient uptake efficiency, predictability, precision as per the requirement of the plant or the media formulations. The fertigation method varies depending on the type of crop, irrigation required and the size and technological status of the greenhouse. The simplest method is to combine soluble fertiliser in a watering container or use a hose injector or sprinkler to water plants by hand. This method is tedious and time-consuming but may be best when growing a variety of species with different fertiliser needs in small area. Therefore, fertiliser injector is relevant for use where fertiliser requirements of large number of plants are nearly uniform.

Fertigation

Fertigation is a precise, controlled and tested method of applying fertilisers, nutrients and other water-soluble products through drip lines and sometimes by micro-sprinkler irrigation systems as per crop requirements, its stage, canopy size, soil or season, etc.

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Advantages of Fertigation

(i) Helps supply both water and fertiliser simultaneously.
(ii) Increases yield by 25–30 per cent.
(iii) Saving in fertilisers by 25–30 per cent.
(iv) Application and distribution of fertilisers uniformly and accurately.
(v) Modifications in nutrient requirement as per crop.
(vi) Lower pH can help in avoiding clogging of drippers.
(vii) Major and micro nutrients can be supplied together with irrigation.
(viii) Requisite amount of fertilisers can be injected in concentration.
(ix) Saves time, labour and energy.

Points to remember for adopting Fertigation

Gravitational fertiliser tank or injection pump such as venturi (a short piece of narrow tube between wider sections for measuring flow rate or exerting suction) are utilised to inject the fertiliser as per plant requirements.

(i) Pressure compensating drippers or inline drippers instead of micro tubes may be used for precision.
(ii) Feeding frequency depends on crop, its stage of growth and season.
(iii) Stock solution should preferably not be above 10 per cent.
(iv) The fertiliser solution should be compatible with other ingredients detailed in subsequent session. Compatibility means mixing ability without precipitation.
(v) Do not inject fertilisers in combination with pesticides or chlorine.
(vi) The time taken by fertiliser supply should not exceed the time given for water supply.

Avoid excess water supply, which may cause the leaching (drain away from soil) of fertilisers.

Fertilisers Suitable for Fertigation

There are a number of soluble fertilisers specifically developed for fertigation. Some of the soluble fertilisers have characteristics that are suitable to specific soil conditions, while others can be used in general for different types of soils. For example, certain soils have over abundance of sulphur, yet may require other nutrients like potassium, calcium and/or magnesium. However, acidic soils require potassium, calcium and magnesium and hence may restrict the use of acidifying fertilisers.

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Nitrogen Sources

Nitrogen is the predominant element used in any kind of fertigation, including the ones used in greenhouses, as plants require it in large quantities besides being highly mobile across different phases of biogeochemical cycles. Nitrogen is used in fertigation from various sources and in different forms. Urea and urea ammonium nitrate solutions are considered the most predominant forms of nitrogen used as fertilisers. Nowadays soluble urea phosphate has also become available in the market. Fertigation through drip or sprinklers should avoid the use of free or anhydrous ammonia (compound containing no water).

Major sources of nitrogen, along with information on their use in fertigation are given below.

Ammonium Phosphate

It may lead to lowering of pH and soil acidification. High calcium or magnesium in the water for irrigation causes precipitate formations and it can choke the drip emitters and drip lines.

Ammonium Sulphate

It is a commonly used fertiliser. It is an inorganic soil supplement that benefits especially in alkaline soils. The active ingredients in it are nitrogen and sulphur. It dissolves readily in water, and is convenient to use for fertigation. It tends to be acid forming, which could be a disadvantage if greenhouse media is acidic.

Ammonium Thio-sulphate

It is used both as a fertiliser and as an acidulating (which makes it slightly acidic) agent. When ammonium thio-sulphate is applied to the soil through fertigation, the

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sulphur-oxidising bacteria, *Thiobacillus* spp., oxidises free sulphur to form sulphuric acid. The sulphuric acid dissolves lime in the soil and forms gypsum. The gypsum makes it easier and helps maintain good porosity and aeration.

Calcium Ammonium Nitrate

It is high in fast acting nitrate-nitrogen, low in lasting ammonium nitrogen, and supplies calcium. Calcium ammonium nitrate may be combined with ammonium nitrate, magnesium nitrate, potassium nitrate and potassium chloride.

Calcium Nitrate

It is soluble in water and causes only a slight shift in the soil or water pH. However, if the water is high in bicarbonate, the calcium content may lead to precipitation of calcium carbonate (lime).

Urea Ammonium Nitrate

Nitrogen is available in three forms — nitrate nitrogen, urea nitrogen and ammonium nitrogen. The nitrate portion is immediately available as soon as it reaches the root zone. The urea portion moves freely with the soil water until it is hydrolysed by the urease enzyme responsible for the formation of ammonium nitrogen.

Urea Sulphuric Acid

It is well suited for fertigation. Urea sulphuric acid is an acidic fertiliser, which combines urea and sulphuric acid. The nitrogen and sulphuric acid contents of these products vary depending on their specific formulation. The advantage of this combination eliminates disadvantages of their use singly. The sulphuric acid decreases losses of ammonia from soil due to volatilisation.

Phosphorus Sources

Monoammonium phosphate, di-ammonium phosphate, monobasic potassium phosphate, ammonium polyphosphate, urea phosphate and phosphoric acid are some of the most common phosphate carrying water-soluble fertilisers. But if applied with high calcium or magnesium concentrations, they can cause precipitation and choking of drip pipes or emitters. The precipitates so formed in drip pipes are fairly stubborn and do not dissolve easily. In order to clean such drip pipes and remove precipitates, the use of phosphoric acid injection is required, which also lowers the pH of the irrigation water. Its use may be advisable only when the pH of the fertiliser-irrigation water mixture remains low. But when the pH is high (due to dilution with the irrigation water) the phosphate may precipitate due to the presence of calcium and magnesium. One approach that is sometimes successful is to supplement the phosphoric acid injections with sulphuric or urea sulphuric acid to assure that the pH of the irrigation water remains low.

Ammonium Nitrate

It is a liquid fertiliser mainly used as a source of nitrogen in greenhouses. It is available in two forms of nitrogen — the nitrate-nitrogen form (mobile and instantly available) and ammonium-nitrogen (the longer lasting, as micro-organisms convert it to the nitrate form).

The major phosphorus sources along with information on their use in fertigation are as follows.

Ammonium Polyphosphate

It can be used as a fertiliser only by low injection rates. If the water being used has high buffering capacity (high carbonate/bicarbonate content generally with high pH, i.e., > 8.0) along with a high calcium and/or magnesium content, possibilities of precipitation in drips becomes very high.

Diammonium Phosphate (DAP)

It is one of the most popular fertilisers as a source of phosphorus and it is completely soluble in water. DAP is a boon under situations of high alkalinity and indeed many greenhouses face this problem.

Mono-Ammonium Phosphate (MAP)

It is also completely soluble in water and is a good source of phosphorus along with some nitrogen for the

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plants. It provides nitrogen in ammonia forms that is taken up by the plants readily.

Monobasic Potassium Phosphate

Also known as monopotassium phosphate, it provides good quantity of phosphorus along with potassium.

Phosphoric Acid

It can be used in many formulations of nitrogen, phosphorus and potassium mixtures. But it cannot be mixed with any fertiliser with high calcium. Being a good source of phosphorus, it provides additional advantage of keeping the pH of input injections low and helps in avoiding precipitation.

Urea Phosphate

It is a good source of both phosphorus as well as nitrogen. It provides nitrogen in the form of urea. It is basically acidic in nature and highly suitable for acidifying water and soil.

Potassium Sources

Most potassium fertilisers are water soluble, and application of potassium through drip irrigation systems has been very successful. The most common constraint is that potassium injection leads to the formation of solid precipitants in the supply tank when potassium is mixed with other fertilisers. The potassium sources most often used in drip irrigation systems are potassium chloride (KCl) and potassium nitrate (KNO_3). Potassium phosphates are avoided for injection into drip irrigation systems.

Major sources of potassium sources along with their uses in fertigation are given below.

Potassium Chloride

Potassium is supplemented by using potassium chloride as it is highly soluble and inexpensive.

Potassium Nitrate

It is costly, but provides both nitrogen and potassium simultaneously. Potassium nitrate is advisable to use with irrigation water where salinity problems exist as it has a low salt index.

Potassium Sulphate

It can easily be used in place of potassium chloride in high-saline areas and simultaneously presents a source of sulphur, if that is required in fertility or soil management programme.

Potassium Thio-sulphate (KTS)

Two grades of potassium thio-sulphate are available and are neutral to basic, chloride-free, clear liquid solution. It is blended with other fertilisers, but KTS mixed should not be acidified below pH 6.0. The correct order of mixing it is to first pour water, then pesticide (if any), and then KTS and/or other fertiliser.

Table 4.2: Composition of major nutrients in different fertilisers commonly recommended for fertigation

S. No.	Fertiliser	N-P-K
1.	Urea	46-0-0
2.	Ammonium Nitrate	34-0-0
3.	Ammonium Sulphate	21-0-0
4.	Calcium Nitrate	16-0-0
5.	Magnesium Nitrate	11-0-0
6.	Urea Ammonium Nitrate	32-0-0
7.	Potassium Nitrate	13-0-46
8.	Mono-Ammonium Phosphate (MAP)	12-61-0
9.	Potassium Chloride	0-0-60
10.	Potassium Nitrate	13-0-46
11.	Potassium Sulphate	0-0-50
12.	Potassium Thiosulphate	0-0-25
13.	Monobasic Potassium Phosphate (MKP)	0-52-0
14.	Phosphoric Acid	0-52-0
15.	NPK	19-19-19 20-20-20

Table 4.3: Solubility of Nitrogenous Fertilisers

S. No.	Types of fertiliser	Nitrogen content (%)	Solubility (gm/litre)
1.	Ammonium Sulphate	21	750
2.	Urea	46	1100

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3.	Ammonium Nitrate	34	1920
4.	Calcium Nitrate	15.5	1290

Table 4.4: Solubility of Potassic Fertilisers

S. No.	Fertiliser	K content (%)	Solubility (gm/litre)
1.	Potassium Sulphate	50	110
2.	Potassium Chloride	60	340
3.	Potassium Nitrate	44	133

Table 4.5: Solubility of Micronutrient Fertilisers

S. No.	Fertilisers	Content (%)	Fertiliser Solubility (gm/litre)
1.	Solubor	20 B	220
2.	Copper Sulphate	25 Cu	320
3.	Iron Sulphate	20 Fe	160
4.	Magnesium Sulphate	10	710
5.	Ammonium Molybdate	54	430
6.	Zinc Sulphate	36	965
7.	Manganese Sulphate	27	1050

Compatibility

Mixing the solutions of two or more water soluble fertilisers can sometimes result in the formation of a precipitate. Therefore, their solutions should be prepared independently in two separate tanks.

Table 4.6: Combined nutrients

S. No.	Fertilisers	Urea	Ammonium Nitrate	Ammonium Sulphate	Calcium Nitrate	Mono Ammonium Phosphate	Mono Potassium Phosphate	Potassium Nitrate
1.	Urea		C	C	C	C	C	C
2.	Ammonium Nitrate	C		C	C	C	C	C
3.	Ammonium Sulphate	C	C		LC	C	C	LC

4.	Calcium Nitrate	C	C	LC		NC	NC	C
5.	Mono Ammonium Phosphate	C	C	C	NC		C	C
6.	Mono Phosphate Phosphate	C	C	C	NC	C		C
7.	Potassium Nitrate	C	C	L	C	C	C	

C = Compatible, NC = Not Compatible, LC = Limited Compatible

Other Macronutrients

Sulphur (S), when needed, can also be provided as ammonium thio-sulphate, ammonium sulphate or flowable S. It is amenable to use with urea ammonium nitrate and other soluble fertiliser grades for drip fertigation. Magnesium sulphate is often used to supply magnesium and sulphur.

Micronutrients

They can be applied readily through the drip system. Sulphates of copper, iron, manganese and zinc are highly water soluble, and move well through the drip system. They are oxidised or precipitated readily in soil, and hence their utilisation can be wasteful. Therefore, it is advisable to use chelated fertilisers which improve micronutrient utilisation efficiency. Chelate forms of fertilisers are generally highly water-soluble and do not choke drips by precipitation.

Fertigation Equipment

Different types of fertiliser application systems through drip irrigation are commercially available. They are venturi, fertiliser tank and piston pump. Selection of a particular fertigation system depends on the area, flow, investing capacity and precision needed. Generally, small cultivators (up to 1008

Fig. 4.8: Fertigation unit

sq m) use venturi due to lower cost, the mid size cultivators (from 1008–4000 sq m) use fertiliser tanks or piston pumps and the big cultivators (more than 5 acre) go for electrical or automation as the initial investment is very high. Further, manual mistakes can be avoided in electrical or automation, besides providing ease of operation. In general, nutrient management is essential during each irrigation.

Calculation of Crop Water Requirement (CWR)

Water is the most critical input under drip irrigation system. Knowledge about calculation of water requirement during crop growth period helps to increase water use efficiency both under open field and protected condition.

Important terminology related to drip irrigation system is as follows.

Fig. 4.9: Pan evaporation

Pan Evaporation

It is evaporation of water from open surface and is recorded at meteorological station on a daily basis and expressed in mm/day. Under protected cultivation, open field pan evaporation is multiplied by a conversion factor of 0.45 to know the actual evaporation inside protected structures.

Pan Factor

It is the factor (0.8) taken to compensate the actual measurement of pan evaporimeter.

Evapotranspiration (ET)

It is water loss through transpiration from plants canopy and evaporation from soil surface. It is expressed in mm/day.

Crop Factor

It is the ratio between the actual and potential evapo-transpiration. It varies as per the crop growth stages.

Crop water requirement for open field and protected cultivation can be calculated by using the following formula. Here ET is in mm/day.

Crop water requirement (m^3/day/ha) = ET * 10 * 0.5 for open field cultivation Crop

Water requirement (m^3/day/1000 m^2) = ET * 1 * 0.5 for protected cultivation

Where, ET (mm/day) = Pan evaporation * Kc (where Kc = crop coefficient)

AVSM (Available soil moisture) or MAD (Management allowable deficit) = 50%=0.5

Calculation of Fertiliser Solution Concentration

The concentration of fertiliser solutions is usually expressed in parts-per million (ppm) of nitrogen. To determine how much fertiliser material is required to produce a solution of a desired concentration, the following formula is used.

Quantity of fertiliser required (grams)

$$= \frac{\textit{Solution concentration (ppm)} \times \textit{solution volume (litres)}}{10 \times (\textit{\% N of fertiliser material})}$$

For example, to make a 100 ppm solution of 20-10-20 fertiliser in a 500 litre tank, the amount of fertiliser required is

$$\text{Quantity of fertiliser required (grams)} = \frac{(100 \times 500)}{(10 \times 20)}$$

Therefore, the quantity of fertiliser required is 250 grams.

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Table 4.7: Fertigation scheduling in flowers under protected cultivation

Crop	Spacing		Plants	Fertigation schedule	Dose			Total			Yield
	Plant to plant (m)	Row to row (m)	No./ $1000m^2$		N	P	K	N Kg/ $1000m^2$	P Kg/ $1000m^2$	K Kg/ $1000m^2$	Stems (No)
Rose	0.2	0.4	12000	Vegetative Stage: September–October	80	50	60	28	17	25	270000
				Flowering and harvesting flush: November–March	100	60	80				
				Flowering and harvesting normal: April–August	80	50	80				
Gerbera	0.2	0.3	16000	Vegetative Stage: September–October	70	50	60	17	12	17	650000
				Flowering and harvesting flush: November–April	80	60	80				
				Maintenance dose: May–August	40	24	40				
Chrysanthemum	0.1	0.15	65000	Vegetative Stage: September–October	80	50	60	21	13	19	90000
				Flowering and harvesting flush: November–April	90	60	80				
				Maintenance Dose: May–August	50	30	50				
Lilium	0.15	0.2	32000	Vegetative Stage: September–October	60	36	60	17	11	17	130000
				Flowering and harvesting flush: November–March	80	50	80				
				Maintenance Dose: April–August	50	30	50				

Carnation	0.15	0.2	32000	Vegetative Stage: September–October	50	30	40	14	08	13	300000
				Flowering and harvesting flush: November–March	60	40	60				
				Maintenance Dose: April–August	40	20	40				

Source: Hasan et al (2010). Fertigation Scheduling for Horticultural Crops. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi. p. 44

Table 4.8: Month-wise fertigation scheduling in flowers under protected cultivation (1000m^2)

Crops	Particulars	Month-wise application of water soluble fertilisers (kg/1000m^2) and Irrigation (No)												
		Jan.	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Total**
Rose														
	Irrigation	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	38.8
	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
	Sulphate of potash (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	49.8
Gerbera														
	Irrigation	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
Chrysanthemum														
	Irrigation	4	6	8	8	8	8	6	6	8	8	6	4	80
	Urea phosphate	1.	2.1	3.7	4.6	2.6	2.7	1.7	1.5	2.5	2.9	3.0	1.9	30.7
	Urea	1.6	2.2	3.9	4.9	3.1	3.3	2.1	1.8	2.9	3.4	3.2	2.0	34.5
	SOP	1.8	2.5	4.3	5.4	3.8	3.9	2.5	2.2	2.6	3.1	3.5	2.2	37.8

Source: Hasan et al (2010). Fertigation Scheduling for Horticultural Crops. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi, p. 44

Table 4.9: Month-wise fertigation scheduling in flowers under protected cultivation ($1000m^2$)

Crops	Particulars	Month-wise application of water soluble fertilisers ($kg/1000m^2$) and Irrigation (No)												
		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Lilium														
	Irrigation	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
Carnation														
	Irrigation	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. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi, p. 44

Practical Exercises

Activity 1: Visit a greenhouse and observe the operation of irrigation and fertigation system

Material required: notebook, pen, etc.
Procedure
- Visit a nearby greenhouse.
- Note down the components of irrigation/fertigation system.
- Note down the sequences of different types of drippers.
- Apply irrigation and fertiliser and observe the process.
- Observe difficulties faced during the operation.
- Discuss with the owner/farmers.

Activity 2: Identification of common fertilisers

Material required: notebook, pen, fertilisers and practical file.
Procedure
- Visit a nearby greenhouse/market.
- Identify fertilisers on the basis of appearance.
- Note down the content of each fertiliser.
- Note down the commonly used water soluble fertiliser.
- Discuss with the owner/farmers.

Check Your Progress

A. Fill in the blanks

1. Application of soluble fertilisers through their irrigation systems is known as _________.
2. The most fertigated element in greenhouses due to high plant nutritional needs is _____________.
3. A liquid fertiliser widely used as a source of nitrogen in greenhouses is ______________.
4. Diammonium phosphate (DAP) is one of the major sources of ___________.

B. Mark the correct answers

1. Which of the following fertilisers may choke the drip due to precipitation, if water is in high carbonate?
   (a) Calcium Nitrate
   (b) Ammonium Sulphate
   (c) Ammonium Nitrate
   (d) Ammonium Thio Suphate

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2. Urea sulfuric acid is an _____________ fertiliser.
   (a) alkaline
   (b) acidic
   (b) saline
   (d) neutral
3. To avoiding clogging of drippers ________ pH is helpful.
   (c) higher
   (b) very high
   (c) medium
   (d) lower
4. Water loss through transpiration from plants canopy and evaporation from soil surface is called _________.
   (a) transpiration
   (b) evaporation
   (c) evapo-transpiration
   (d) respiration

C. Descriptive questions

1. Describe major nitrogen sources and their use in fertigation.

____

____

____

2. Write in brief
   (a) Micronutrients
   (b) Fertigation equipment
   (c) Crop water requirement

____

____

____

D. Match the columns

A	B
1. Source of N and P	(a) Ammonium Thio Sulphate
2. Good source of Calcium	(b) Calcium Ammonium Nitrate
3. Lower pH	(c) Potassium Nitrate
4. Supplies K	(d) Urea Phosphate

Floriculturist (Protected Cultivation)-Class 11- Unit 4 Session 1

A. Fill in the blanks

1. Commonly available diameter of laterals in India is _________ and ________ mm.
2. For potted plants stake drippers of discharge ______ LPH for each pot is used.
3. Sprinklers used on the top of greenhouse helps in ____________.
4. Normally pH of irrigation water should range between ____________.
5. Normally, in greenhouse the number of carnation plants per sq m is __________.
6. Water requirement of rose plants is ____________ per sq m/day.

B. Mark the correct answers

1. A method of irrigation in which use of less water precisely to the crop is __________.
   (a) Flood irrigation
   (b) Macro irrigation
   (c) Basin irrigation
   (d) Micro irrigation
2. Which of the following can adjust pressure but not control leakage?
   (a) NPC dripper
   (b) PC dripper
   (c) PCCNL dripper
   (d) None of these

C. Descriptive questions

1. What is quality of water?

____

____

____

2. What is drip irrigation system? Write some of its benefits.

____

____

____

3. Write in brief
   1. Micro irrigation system and its application
   2. Sprinkler system

D. Match the columns

	A		B
1.	Drip irrigation	(a)	Nozzles and dripper
2.	Emitters	(b)	pH and EC
3.	Water quality	(c)	Trickle irrigation
4.	Sprinkler	(d)	Water let out

Floriculturist (Protected Cultivation)-Class 11- Unit 4 Session 2

A. Fill in the blanks

1. Application of soluble fertilisers through their irrigation systems is known as ________.
2. The most fertigated element in greenhouses due to high plant nutritional needs is ____________.
3. A liquid fertiliser widely used as a source of nitrogen in greenhouses is ______________.
4. Diammonium phosphate (DAP) is one of the major sources of __________.

B. Mark the correct answers

1. Which of the following fertilisers may choke the drip due to precipitation, if water is in high carbonate?
   (a) Calcium Nitrate
   (b) Ammonium Sulphate
   (c) Ammonium Nitrate
   (d) Ammonium Thio Suphate
2. Urea sulfuric acid is an _____________ fertiliser.
   (a) alkaline
   (b) acidic
   (b) saline
   (d) neutral
3. To avoiding clogging of drippers ________ pH is helpful.
   (c) higher
   (b) very high
   (c) medium
   (d) lower
4. Water loss through transpiration from plants canopy and evaporation from soil surface is called _________.
   (a) transpiration
   (b) evaporation
   (c) evapo-transpiration
   (d) respiration

C. Descriptive questions

1. Describe major nitrogen sources and their use in fertigation.
2. Write in brief
   (a) Micronutrients
   (b) Fertigation equipment
   (c) Crop water requirement

D. Match the columns

	A	B
1.	Source of N and P	(a) Ammonium Thio Sulphate
2.	Good source of Calcium	(b) Calcium Ammonium Nitrate
3.	Lower pH	(c) Potassium Nitrate
4.	Supplies K	(d) Urea Phosphate

Unit 5

Greenhouse Operations

Introduction

A greenhouse environment for achieving the required level of precision and efficiency is bound to be complex and dynamic. To be able to dynamically control the environmental parameters of the micro climate inside a greenhouse, it requires huge cost, trained labour while all along being market sensitive. Therefore, entire range of greenhouse control and automation are key elements of success in terms of profitability. Since most of the environmental controls and biological dynamics of plant metabolism are often interdependent, these controls become crucially important for successful greenhouse production. If we can control critical components and factors under dynamic and precise automation, then only the desirable efficiency of micro climate inside the greenhouse can be called successful.

For effective production under greenhouses, the following environmental operations and their regulations are essential.

(i) Temperature
(ii) Light intensity
(iii) Relative humidity
(iv) pH and EC
(v) Carbon dioxide
(vi) Ventilation

Session 1: Equipment for Environmental Parameter Monitoring in Greenhouses

Greenhouse cultivators strive to maximise their production from a limited space covered. To achieve their goal, cultivators purchase inputs and avail best of the know-how to operate several tools to avoid making serious mistakes during the course of crop production. For measuring different environmental parameters, the required equipment/instruments are described below.

Thermometers

Fig. 5.1: Infrared Thermometer

A minimum/maximum thermometer is a must for greenhouse growers. The temperature in the greenhouse has a great influence on nutrient uptake, plant growth, pollination, fruit set, fruit cracking, discolouration, flower size, stem length, etc. The thermometer is located at the centre of the greenhouse and at the plant level, not facing the sun. Optimum temperatures for flower cultivation range between 18–26 °C.

Humidity meters

Fig. 5.2: Hygrometer

These meters are used to adjust the desired level of relative humidity. Best crop growth can be achieved when humidity ranges between 60 and 80 per cent.

High relative humidity in the greenhouse results in less transpiration leading to less movement of nutrient. If the levels of humidity are above and below the desired level, it results in high incidence of pests and diseases. Hygrometer is used for measuring atmospheric humidity and temperature.

pH meters

Fig. 5.3: pH meter

Ideally, the pH of the soil and water has to be 6–6.5 and that of nutrient solution should be 5.6–6.5. A good quality pH meter should be used to regularly check the pH of the nutrient solution as well as the pH of the growing medium. The pH meter, like all other equipment, should be calibrated beforehand for accurate data collection. At a low pH, the hydrogen ions saturate media exchange sites and increase the potential for leaching and losing nutrient content such as calcium, magnesium, potassium and ammonium. A high media pH can cause micronutrient deficiencies even when they are present in sufficient quantity.

Electrical conductivity (EC) meter

EC is a measure of soluble salts in water and is measured in terms of millimhos per centimetre (mmhos/cm), deciSiemens per metre (dS/m), or milliSiemens per centimetre (mS/cm). They are all indeed similar on numerical count, i.e., numerical value remains same per unit area, only the reference varies. An analysis should be done for the nutrient feed solution and for the root medium. The EC measurement alone does not indicate the types of fertiliser in the nutrient solution, but this measurement can provide a good indication of the total amount of fertiliser being applied. A root-zone EC of above 1.0 mS/cm should alert cultivators about starting of salt build-ups. It necessitates flushing the growing medium. It is important to know the EC of water before mixing the fertiliser.

Lux meter

It is used for measuring the intensity of light in the greenhouse. Lumen is the metric unit of light intensity and the term lux refers to the number of lumens per sq m of surface area.

Fig. 5.4: Lux meter

CO_2 Enrichment or Maintenance

Portable CO_2 meters are commercially available to monitor carbon dioxide concentration. Generally, the value of carbon dioxide inside the polyhouse is around 1000 ppm in the morning hours and declines as the day progresses. The presence of more quantities of carbon dioxide helps in enhancing the net photosynthetic rates. Operation of side curtains in naturally ventilated greenhouses helps in the replacement of reduced carbon dioxide levels naturally.

NOTES

Practical Exercises

Activity 1: Measurement of temperature inside a greenhouse.

Materials required: thermometer, pen, notebook, etc.
Procedure

- Visit a greenhouse in nearby area after consulting the farmer.
- Take a digital thermometer to monitor the temperature at different locations and height inside the greenhouse.
- Measure the temperature just above the ground level, at crop height level and at about 4 m height.
- Note down the readings at entry point, mid of the greenhouse and at the farthest point.
- Observe the difference in temperatures at different locations inside the greenhouse.

Check Your Progress

A. Fill in the blanks

1. Ideally, the pH of the nutrient solution should be between __________ and ____________.
2. Generally, the value of carbon dioxide inside a polyhouse during early day hours would be around ______ ppm.
3. Best crop growth of flowers can be achieved when humidity ranges between _______ and ____________ %.
4. Optimum temperatures for flower cultivation range between ________ and ________.

B. Mark the correct answers

1. High media pH can cause deficiencies of ________.
   (a) micronutrient (b) water
   (c) humus (d) plant hormone
2. Measuring soluble salts in water is ________.
   (a) Co_2 (b) pH
   (c) EC (d) Temperature
3. Which of the following does not come under environmental parameters?
   (a) Humidity (b) pH
   (c) Light (d) Temperature

C. Descriptive questions

1. Describe the equipment used for environmental parameters monitoring in greenhouses.

____

____

____

D. Match the columns

	A	B
1.	Humidity and temperature	(a) 6–6.5
2.	Ideal EC in greenhouse soil	(b) Hygrometer
3.	Ideal pH of soil and water	(c) Lux meter
4.	Measuring light intensity	(d) >1 in mS/cm

Session 2: Management of Environmental Parameters in a Greenhouse

Climatic parameters and their management are essential for quality and quantity of greenhouse crop production. These parameters can be managed and regulated naturally as well as artificially by using different equipment. The equipment may be operated manually, hydraulically or electrically. The type of climate control systems used also depends on the size and number of the greenhouses.

The use of a particular equipment or their combinations depend on the type of crop grown and the type of greenhouse suitable for its cultivation. The equipment can be low-cost, manually operated to auto controlled high-cost systems.

The purpose of using different systems inside the greenhouse could be for cooling, heating, lowering or enhancing humidity, enriching gaseous composition, lighting, irrigation, fertigation, fogging, pesticide spraying, etc.

Table 5.1: Equipment/System and its function used in protected cultivation

Purpose	Equipment/System and its function	Parameters that are managed inside the greenhouse
Cooling	**Equipment/System used: Vents/Side Curtains** **Function:** Heat inside the greenhouse escapes through top vent and fresh air enters the structure through side windows when side curtains are opened. This can be done manually or with actuators which can be operated electrically. **Shade net Function:** Cooling can also be achieved by collapsible shade nets that can be operated manually or mechanically inside the greenhouse.	Temperature, relative humidity and gaseous composition

	Fogging Function: Cooling can also be achieved through operation of foggers for increasing humidity inside the structure. The result is a cooling effect due to evaporation. However, it should be used cautiously when targeted to control temperature and droplet formation on leaves has to be avoided.	
Ventilation	**Equipment/System used** **Vents/Side curtains** **Function:** Air inside the greenhouse can be exchanged continuously with cross ventilation, natural air convection or artificial forced ventilation. **Exhaust fan and pad** **Function:** These systems are used in forced ventilated systems. These systems can be operated manually or with actuators which can be operated electrically.	Temperature, relative humidity and gaseous composition
Shading	**Equipment/System used** **Function:** Shade nets of different shading percentages are used to normally reduce the light intensity during the critical crop stages as per the requirement of the crop. Different crops require different percentage of shading. Shading can be achieved by installing and operating the collapsible shade nets inside the greenhouse. Spreading and rolling back of shade nets preferably outside the structure can be achieved manually or by electrical actuators. While silver shaded nets are installed inside the greenhouses which can be opened (spread) during intense sunlight and cloudy days, these are closed during cold nights.	Light intensity, temperature
Humidity	**Equipment/System used** **Foggers/De-humidifier Function:** These are used for regulating the humidity inside the greenhouse as per the crop requirement. Foggers are used to increase the humidity levels inside the structure. These can also be used to bring down the temperature inside the structure. Alternately, de-humidifiers are used to decrease the humidity inside the structure, when the humidity levels are above the desired levels. Though it is rare. **Hygrometer/Hygrothermometer:** Hygrometer is used to measure atmospheric relative humidity inside the greenhouse. Hygrothermometer is used to measure atmospheric temperature and relative humidity both inside the greenhouse. Portable digital type instruments are commercially available for use.	Humidity, temperature

Carbon dioxide	**Equipment/System used** **Side curtains closing, CO_2 Burner, CO_2 Cylinders, Fuel Gases** **Function:** Management of carbon dioxide inside the greenhouse is possible with the closing of side curtains in the evening hours till morning. CO_2 released by the plants naturally during the night can be trapped and accumulated for its use by plants in the day. CO_2 burners, CO_2 cylinders, fuel gases can also be used for artificial enrichment of carbon dioxide levels, though they are rarely used.	Carbon dioxide
Heating	**Equipment/System used** **Central heating systems or localised heating systems** **Function:** Heating systems are used to generate heat where the outside atmosphere has near zero or sub-freesing temperatures. In India, heating systems are rarely used. The natural heat can also be conserved inside the greenhouse by closing the side curtains in the evening hours till morning in the winter season.	Heat, temperature
Lighting/ Darkening	**Equipment/System used** **Lamps/Black nets** **Function:** Some crops need longer or shorter day or nights for their critical growth at the flowering and fruiting stage. This happens naturally only during summers and winters, however, this can managed with artificial lights for increasing day hours, and black nets to increase night hours for year round production inside the greenhouse. The artificial lighting can include incandescent, fluorescent, mercury or halide lamps.	Light
Climatic parameters and quality measuring instruments	**Lux meter:** It is used to measure the visible light intensity inside the greenhouse. It consists of silicon plate to sense the light. The unit of measurement is in Lux. **pH meter:** It is used to measure acidity or basicity of the soil and water used in greenhouse cultivation. **EC meter:** It is used to measure the dissolved salts in soil, and water used in greenhouse cultivation. This is measured in dS/m or milli Mhos/cm. **Thermometer:** It is used to measure temperature inside the greenhouse. Portable digital thermometers are commercially available. The unit of measurement is °C. **Portable observatory:** All the greenhouse parameters such as temperature, humidity, light, wind speed and wind direction can also be measured with portable observatory. This helps take decision to regulate the climatic parameters inside the greenhouse.	Light, pH, EC and relative humidity

Irrigation and fertigation	**Drip Irrigation and Fertigation System** These consist of suitable drippers, emitting pipes, piping network and control valves, filtration unit, fertigation equipment and pump. **Functions:** These are used to supply quality irrigation water precisely and timely right up to the base of the plant as per the daily water requirement of the crop. This can be controlled using control valves which can be operated manually or automatically depending on the type of crop and technology used. Filters are used to filter the irrigation water used from different sources. These filters are installed at the header unit before the injection of water inside the piping network. Common type of filters used are sand filter, hydro cyclone filter and disc/screen filters. These filters can be operated manually or automatically. Fertigation equipment is used to inject soluble/liquid fertilisers, pesticide/fungicides, chemicals inside the drip system accurately and timely as per the need of the crop. The commonly used fertigation equipment include venturi, fertiliser tank, injection pump and electrically or hydraulically operated dozers.	Optimum amount of water and doses of macro and micro nutrients as per the requirements of crop and crop stage

Practical Exercises

Activity 1: Monitor humidity and temperature in greenhouse

Material required: humidity meter or hydro-thermometer, thermometer pen, notepad, etc.

Procedure

- Visit a greenhouse in nearby area after consultation with a farmer.
- Measure the temperature and humidity of greenhouse immediately after entering.
- Open the side curtains and after 30 minutes measure the temperature and humidity.
- After that ask the farmer to operate the fogger for 30 seconds.
- Measure the temperature and humidity again.
- Observe the temperature and humidity values that you collected.

Check Your Progress

A. Fill in the blanks

1. Humidity is regulated inside the greenhouse by ________.
2. To increase night hours in the greenhouse round the year is ___________ used.

3. Net used to reduce the light intensity is known as ______________.

B. Mark the correct answers

1. Hygrometer is used to measure ______________.
   (a) pH
   (b) Relative Humidity
   (c) EC
   (d) Light intensity
2. An equipment used in forced ventilated system is ____________.
   (a) exhaust fan and pad system
   (b) sensors
   (c) CO_2 burner
   (d) de-humidifier
3. The presence of more quantities of carbon dioxide helps in enhancing the ______________.
   (a) respiration rate
   (b) transpiration rate
   (c) photosynthetic rates
   (d) evaporation rate

C. Descriptive question

1. Describe different equipment and their functions used in protected cultivation.

____

____

____

D. Match the columns

	A		B
1.	EC	(a)	Fogger
2.	Cooling equipment	(b)	Venturi
3.	Decrease humidity	(c)	dS/m
4.	Fertigation equipment	(d)	De-humidifier

Notes

Floriculturist (Protected Cultivation)-Class 11- Unit 5 Session 1

A. Fill in the blanks

1. Ideally, the pH of the nutrient solution should be between __________ and ___________.
2. Generally, the value of carbon dioxide inside a polyhouse during early day hours would be around ______ ppm.
3. Best crop growth of flowers can be achieved when humidity ranges between _______ and ___________ %.
4. Optimum temperatures for flower cultivation range between ________ and ________.

B. Mark the correct answers

1. High media pH can cause deficiencies of ________.
   (a) micronutrient (b) water
   (c) humus (d) plant hormone
2. Measuring soluble salts in water is ________.
   (a) Co_2 (b) pH
   (c) EC (d) Temperature
3. Which of the following does not come under environmental parameters?
   (a) Humidity (b) pH
   (c) Light (d) Temperature

C. Descriptive questions

1. Describe the equipment used for environmental parameters monitoring in greenhouses.

____

____

____

D. Match the columns

A	B
1. Humidity and temperature	(a) 6–6.5
2. Ideal EC in greenhouse soil	(b) Hygrometer
3. Ideal pH of soil and water	(c) Lux meter
4. Measuring light intensity	(d) >1 in mS/cm

Floriculturist (Protected Cultivation)-Class 11- Unit 5 Session 1

A. Fill in the blanks

1. Humidity is regulated inside the greenhouse by ________.
2. To increase night hours in the greenhouse round the year is __________ used.

3. Net used to reduce the light intensity is known as ______________.

B. Mark the correct answers

1. Hygrometer is used to measure ______________.
   (a) pH
   (b) Relative Humidity
   (c) EC
   (d) Light intensity
2. An equipment used in forced ventilated system is ____________.
   (a) exhaust fan and pad system
   (b) sensors
   (c) CO_2 burner
   (d) de-humidifier
3. The presence of more quantities of carbon dioxide helps in enhancing the ______________.
   (a) respiration rate
   (b) transpiration rate
   (c) photosynthetic rates
   (d) evaporation rate

C. Descriptive question

1. Describe different equipment and their functions used in protected cultivation.

____

____

____

D. Match the columns

	A		B
1.	EC	(a)	Fogger
2.	Cooling equipment	(b)	Venturi
3.	Decrease humidity	(c)	dS/m
4.	Fertigation equipment	(d)	De-humidifier

GLOSSARY

Bulbous plant: *In nature there are certain plants which have modified underground stem in which food material in stored to overcome the unfavourable season. In Horticulture the plants which are propagated through modified under-ground storm are called as Bulbous plants.*

Cladding Material: *Covering material of the greenhouse, i.e., polythene, shade net or polycarbonate, etc.*

Clogging: *Blockage*

Coco peat: *Growing medium prepared from dried powder of coconut plant fibres*

Compatibility: *Miscibility or mixing ability without precipitation*

Crop-water-requirement: *the water requirement of the crop, which includes transpiration of the crop, as well as, direct evaporation from the soil.*

Dolomite lime: *It is a rock which consists of calcium magnesium carbonate. Dolomite lime fertiliser is certainly allowed in organic gardening.*

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.*

EC (Electrical conductivity): *The measurement of salt content in the extracted soil water when the soil is saturated with water expresser in millimhos per cm.*

Evapo-transpiration: *It is water loss through transpiration from plants canopy and evaporation from the soil surface and expressed in mm/ day.*

Fertigation: *Artificial fertiliser application in a closed irrigation system. Pesticides and fungicides can also be applied in this way.*

Greenhouse effect: *A phenomenon in which the atmosphere traps radiation, caused by gases such as carbon dioxide, water vapour and methane (by polythene in a polyhouse) that allow more sunlight to pass through but less to return back from the earth's (greenhouse) surface.*

Gutter: *Channel for collecting water for run-offs from the roof of plants in a soil is reached when the suction force of plants cannot overcome tension by which groundwater is tied by the soil. At this point plants start to wilt.*

Hygrometer: *Device to measure relative humidity*

IR-Transmission: *Penetrability of heat radiation through plastic films*

Lux Meter: *Device to measure light intensity*

Micronutrients: *Nutrients which are required by plants in very minute dosages or in traces only.*

Multi-span greenhouses: *Greenhouses with more than two attached covers (tunnels)*

Multi span: *It refers to more then two interior column or multiple standing columns to support structure*

Pan evaporation: *It is the evaporation of water from open surface and is recorded at meteorological station on a daily basis and expressed in mm/ day, under protected.*

Peat: *A brown colour material consisting of partly decomposed vegetable matter forming a deposit on acidic, boggy, ground, which is dried for use in gardening and as fuel.*

Perlite: *White granular particles formed when volcanic mineral rock is heated quickly, causing it to expand. It is used in many potting mediums.*

pH or Soil reaction: *pH is a measure of hydrogenion concertration; a measure of the acidity or alkalirity of a solution.*

pH-meter: *digital meter (in pocket size) to measure the acidity in moist soil. The most favourable levels are in the range between 6 and 7.*

Protected Cultivation: *Cultivation of crops under protected structures like glasshouses, polyhouses, tunnels, shade nets for protection from biotic and abiotic stress for a healthy production system.*

Pro-tray: *Plastic trays used for soilless production of nursery*

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

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

Single span: *A gap between two supports, single span structure has a single interior column or free standing structure.*

Sphagnum moss: *It is commonly known as peat moss. Mosses that belong to the sphagnum genus are known for their high water retention potential. As sphagnum can absorb water rapidly and maintain the moisture content, it allows the succulents to stay hydrated.*

Substrate: *The surface or material on which an organism lives, grows, or obtains its nourishment.*

Transpiration: *The sum of water physiologically evaporated or transpired by the plant*

Vacuum-effect: *A strong stream of air over the greenhouse cover, which induces lower air pressure within the greenhouse.*

Ventilation box: *Box protecting against sunlight allowing for free airflow in protected cultivation*

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

Vermiculite: *It is a yellow or brown mineral found as an alteration product of mica and other minerals, used for insulation or as a moisture-retentive medium for growing plants.*

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

NOTES

Further Readings

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Answer Key

UNIT 1: Introduction to Protected Cultivation

Session 1: Importance of Protected Cultivation

A. Fill in the blanks

1. Export quality
2. High rainfall area
3. Protected structure
4. Protected structure

B. Mark the correct answers

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

C. Match the columns

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

Session 2: Site Selection and suitable crops for Protected Cultivation

A. Fill in the blanks

1. 6.0 to 6.5
2. 10–15 m
3. Four
4. Self-pollinated
5. Standard type

B. Mark the correct answers

1. (b) North–South
2. (b) Western
3. (a) 40:60

C. Match the columns

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

UNIT 2: Types of Protected Structures and their Components

Session 1: Types of Protected Structures

A. Fill in the blanks

1. Miniature
2. Up to 1 m high
3. 200 micron
4. 2–2.5 metre
5. 40 or 50 mesh

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B. Mark the correct answers

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

C. Match the columns

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

Session 2: Classification of Greenhouses

A. Fill in the blanks

1. Greenhouse
2. Bamboo or Wooden
3. Fan, Pad and heaters
4. 6.5–7
5. High cost

B. Mark the correct answers

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

C. Match the columns

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

Session 3: Major Components of Greenhouse

A. Fill in the blanks

1. Cladding material
2. Collecting
3. UV stabilised

B. Mark the correct answers

1. (b) 2. (a)

C. Match the columns

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

UNIT 3: Preparation of Media and Container for Commercial Cultivation in Greenhouses

Session 1: Growing Media and its Composition

A. Fill in the blanks

1. Coco peat
2. Perlite
3. Calcium and magnesium
4. 3:1:1
5. Vermiculite

B. Mark the correct answers

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

C. Match the columns

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

Session 2: Sterilisation of Growing Media

A. Fill in the blanks

1. Soil sterilisation
2. Formaldehyde
3. 35–40

B. Mark the correct answers

1. (a) 2. (c)

C. Match the columns

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

Session 3: Preparation of Beds and containers for growing crops

A. Fill in the blanks

1. Clay pot
2. Pro-trays

B. Mark the correct answers

1. (c) 2. (d)

C. Match the columns

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

UNIT 4: Irrigation and Fertigation in Greenhouses

Session 1: Micro Irrigation Systems and their Application under Protected Cultivation

A. Fill in the blanks

1. 12 mm and 16 mm
2. 1
3. Cleaning dust
4. 6.5–7.0
5. 20
6. 3–4 liters

B. Mark the correct answers

1. (d) 2. (c)

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C. Match the columns

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

Session 2: Types of Fertilisers and their Scheduling

A. Fill in the blanks

1. Fertigation
2. Nitrogen
3. Ammonium nitrate
4. Phosphorus

B. Mark the correct choice

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

C. Match the columns

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

UNIT 5: Greenhouse Operations for Environmental Control

Session 1: Equipment for environmental parameters monitoring in greenhouses

A. Fill in the blanks

1. 5.6–6.3
2. 1000
3. 60–80
4. 18–26 °C

B. Mark the correct choice

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

C. Match the columns

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

Session 2: Management of Environmental Parameters in Greenhouse

A. Fill in the blanks

1. Fogger
2. Black net
3. Shading net

B. Mark the correct answers

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

C. Match the columns

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