Floriculturist
(Open Cultivation)

Job Role

Qualification Pack Ref. Id. SSC/Q0501
Sector: Agriculture

Textbook for Class XI

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एन सी ई आर टी
NCERT
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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 the country's GDP and occupies almost 43 per cent of India's geographical area. The Agriculture Industry employs a large number of people in the organised and the unorganised sector. The requirement of skilled workforce in this sector is increasing day-by-day. The various job roles such as Floriculturist — open cultivation, Floriculturist — protected cultivation, Tuber Crop Cultivator, Micro Irrigation Technician, Solanaceous Crop Cultivator, etc., are in demand by the States for preparing skilled manpower.

Floriculturist (Open Cultivation) is a person who undertakes various activities of flower cultivation in open field condition, which involves preparation of the field, seed bed, planting, transplanting, selection of flower crops, and caring of flower crops. Floriculturist performs maintenance operations such as thinning, weeding, irrigation, fertigation, controlling pests and diseases, etc. 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 return.

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

The textbook has been developed with the contribution of expertise from subject and industry experts, vocational teachers, and academicians for making it a useful and inspiring teaching-learning resource material for 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 student acquires 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 NOSs, but is also of high quality. The NOSs for the job role of Floriculturist (Open Cultivation) covered through this textbook are as follows:

1. AGR/N0701 Preparatory Cultivation of Flower Crops
2. AGR/N0702 Crop Cultivation in Flower Crops

Unit 1 of this textbook introduces floriculture, its importance, present status and prospects of floriculture in India, classification of ornamental plant, etc. Unit 2 focusses on nursery and its importance, growing media, nursery bed preparation, seed sowing and planting material. Unit 3 deals with the tools and implements used in land preparation. Unit 4 focuses on soil and its properties, tillage and cultural operations. Unit 5 deals with plant nutrients, application of manures and fertilisers, irrigation and drainage. Unit 6 focsses on insect pest, disease and weed management.

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

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

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The images 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.

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*, Sweta Jha, *Editor* (Contractual) and Garima Syal, *Proofreader* (Contractual) for copyediting. The 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 Floriculture

Introduction

Floriculture is a vast field that includes cultivation and production of all types of ornamentals, viz., croton, cacti, orchids, grasses and bamboos. Besides cultivation, it includes layout and designing of gardens, study of various styles and features of garden and landscaping. The various field of revenue generation in floriculture includes cut flower production, loose flower production, nursery plants, potted plants, seed industry and extraction of essential oils. It has the potential for generating employment opportunities round the year and earning livelihood and valuable foreign exchange. India exports many floricultural products such as cut flowers, potted plants, etc., to many countries of the world. Export of floricultural items is important for our country's economy. About 30 per cent of the economy of a small country, like Holland, is based on the export of cut flowers.

Floriculture

Floriculture is a branch of horticulture that deals with the cultivation, processing and marketing of ornamental plants, vis-a-vis landscaping and maintenance of gardens so that surroundings may appear aesthetically pleasant.

Floriculture in the Indian economy

- According to the National Horticultural Board Database, (2016–17) the leading flowers producing States in the country are — Tamil Nadu (19%) followed by Karnataka (13%) and West Bengal (12%).
- Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan, West Bengal have emerged as major floriculture centres (APEDA, 2016–17).
- The share of floricultural products in total horticultural produce is 1.1% (NHB Database, 2015–16).
- About 2184.0 ('000 MT) flower production was estimated with the area of 278.0 ('000 ha) (NHB Database, 2015–16).
- Loose and cut flowers share in the total flower production is 1656.0 ('000 MT) and 528.0 ('000 MT), respectively (NHB Database, 2015–16).
- The highest production of flowers was recorded in Tamil Nadu (416.63 thousand tonnes), followed by Karnataka (280.92 thousand tonnes) (NHB Database, 2015–16).
- The annual growth trend of area and production of horticulture crops are 11.6% and 1.9%, respectively (NHB Database, 2016–17).
- At present, the share of the Indian floriculture products in the international market is about 0.6% (APEDA, 2015–16).
- India's total export is 22,000 metric tonnes of floriculture products with the worth of 548.74 crore in 2016–17. Major export destinations are the United States, Germany, the United Kingdom, the Netherlands and the United Arab Emirates (APEDA, 2016–17).
- There are more than 300 flower export-oriented units in India and more than 50% of the floriculture units are based in Karnataka, Andhra Pradesh and Tamil Nadu (APEDA).

- As per the ITC Trade Map, International Trade Statistics, 2014, India stands 14th in the world in exporting floricultural products, while the Netherlands and Columbia rank first and second, respectively.

Importance of floriculture

Floriculture is one of the most potential components of the horticulture industry, being important from aesthetic, social and economic points of view. The importance of commercial floriculture are as follows:

(a) Production of cut flower

Cut flowers are harvested with stalk, especially for arrangement in vases. These are long-lasting and constitute a major share of the total world trade in floricultural products. Important cut flower crops are—rose, carnation, chrysanthemum, orchid, gerbera, lily, gladiolus, tulip, narcissus, bird of paradise, heliconia, anemone, ranunculus, tulip, calla lily, etc. Cut flowers are used in bouquet preparation or floral baskets, as corsages, in landscape gardening, flower arrangement and for decoration.

(b) Production of loose flower

Loose flowers are plucked from plants just below the calyx. These do not have attached stalks. Loose flowers are in great demand, especially in Asian countries for making *veni*, *rangoli*, bracelets, hair adornments for women and garlands, religious offerings and decorative purposes at various social functions. Loose flowers comprise rose, chrysanthemum, marigold, jasmine, tuberose, gaillardia, crossandra, barleria, *chandni*, *kaner*, hibiscus, spider lily, eranthemum, etc.

(c) Production of cut greens

Cut greens or cut foliage (leaves and stems) are attractive in form, colour and freshness. These are long-lasting and in great demand in floriculture trade. These are used as filler with cut flowers in flower arrangement,

and elsewhere for increasing aesthetic value. They have various uses in fresh and dried floral designs and floral ornaments, such as bouquets, wreaths, interior decoration, etc. Some of the cut foliages in demand are asparagus, ferns, thuja, cupressus (goldcrest), eucalyptus, etc.

(d) Potted plants

These are of considerable commercial importance for instant gardening and for indoor, as well as, outdoor decoration. Potted plants can be carried wherever needed. These may be either of ornamental foliage or flowering. They are used for indoor decoration at homes, offices, commercial complexes, corporate offices, hotels, malls, and for decoration of sites during various functions or occasions. The importance of these plants is increasing because with the growing population and lack of open spaces, one has to largely depend on potted plants for decorating their surroundings. Examples of potted plants are—aglaonema, aralia, azalea, calathea, chlorophytum, croton, diffenbachia, dracaena, ferns, ficus, kalanchoe, maranta, money plant, senecio, syngonium, etc.

(e) Flower seeds and planting materials

There is a lot of demand for good quality flower seeds, especially annual ornamentals and ornamental planting materials. Availability of a great variety of soil and climatic conditions enables seed production of practically all types of flowers. Flower seeds of annuals are produced in large numbers for sale. A large number of bulbous plants, such as gladiolus, tuberose, amaryllis, dahlia, lilies, freesia, tulip, calla lily, etc., are multiplied and marketed.

(f) Nursery

Nurseries are meant for multiplying and supplying plants and planting materials. Ornamental plant nursery is a lucrative retail or wholesale business for supplying various types of plants and planting materials. Planting materials include nursery seedlings or prepared plants of trees, shrubs, climbers, annual

seedlings, perennials, foliage plants, bulbous plants, cacti and other succulents, palms, plants for indoor decoration, grasses, seeds, bulbs, etc.

(g) Lawn

It is a well-mown turf made in the field, in front of a house, open space or in a garden. Lawn is made for various purposes and for providing clean air and elegant environment. A lawn is an integral part of garden, providing a beautiful environment for onlookers and emitting fresh oxygen to the environment as a lung does for the body. It has aesthetic and recreational value. It is believed that lawns improve the value of property by 15 to 20 per cent. It improves curb appeal. Various kinds of grass can be used according to the purpose of lawn use, like golf, hockey, badminton, tennis, etc.

(h) Production of perfumes

The demand for natural floral extracts, like perfumes, from flowers, is increasing by the day. Some flowers, such as rose, jasmine, screw pine and tuberose are used for the extraction of essential oils, which are a base for the preparation of perfumes, scents or attar. These flowers are produced for the extraction of high-grade floral perfumes.

(i) Dried flowers

Since fresh cut flowers and cut foliage are comparatively short-lived and have limited availability period, dry flower technique is used, wherein flowers can be easily dried, preserved and processed to retain its beauty, as well as, value for a longer period of time. The common examples of air-dried and mostly used as dry flowers include acroclinum, dahlias, larkspur, helichrysum, lotus pods, etc. In floricultural exports from India, these products constitute 60–70 per cent.

(j) Extraction of colour pigments

Flowers are used to extract natural pigments. Carotenoids, extracted from flowers, are used

commercially in pharmaceuticals, food supplements, and animal feed additives and as food colourant. In poultry industry, for intensifying the yellow colour of egg yolk, petals of marigold are used as a feed additive. It is also used to prevent diseases of the eye in humans. From chrysanthemum flower, a yellow-coloured dye is extracted for use in food products and cosmetics. The arils of Achiote (Bixa orellana) is used in cosmetics and medicines for coating having orange red colour dye.

(k) Pollution-free environment

The role of open spaces like parks and plants in checking air pollution is a well-known fact. Parks are considered as the lungs of cities. Ornamental plants help improve the environment aesthetically and health-wise. Some trees have been found to be useful in preventing air and noise pollution in urban areas. Trees provide shade and create better microclimate. Parks or gardens also serve as recreation spots and are known to have positive effect on physical and mental health apart from providing a peaceful atmosphere for meditation.

Aesthetic value of flowers

'Aesthetic' is the perception of beauty and study of its appreciation. Aesthetic value may be defined as the theory of the level of beauty of certain natural resources. It is the value or pleasure that anything beautiful gives to humans. Flowers symbolise passion, purity, beauty, innocence, peace, love, adoration, etc., and are well-proofed for their aesthetic value. Some common aesthetic values of flowers are as follow:

(a) Psychological

Flowers bring feelings of peace and comfort when given to an ailing member at home or in hospital or rehabilitation centres, and to family members or friends in general. They help in achieving higher level of personal development and satisfaction.

(b) Landscaping

Landscaping is the treatment of waste or otherwise free land with a goal to make it attractive and beautiful.

Landscaping is becoming common as it improves the environment of an area, brings in calmness, freshness and increases aesthetic value. This is important for offices, residences, supermarkets, etc., as the first look of a building's exterior is expected to give a pleasant overall appearance. Parks and gardens provide an opportunity for a large number of people to relax and enjoy the beauty of nature. A lawn is an integral part of a garden and is primarily for aesthetic purpose.

(c) Indoor gardening

Growing plants inside a house is known as indoor gardening. It not only makes the appearance of indoors beautiful, pleasant and attractive but also improves the air quality and adds freshness to an area.

(d) Flower arrangement

Flower arrangement is the aesthetic and artistic form of flower display, which refreshes the mind. It provides a means of livelihood to the arranger. Cut and loose flowers are used for various flower arrangements and can be presented on various occasions, such as weddings, birthdays, etc. They add beauty to the table when used as a centrepiece.

Prospects and present status of floriculture in India

- Due to the changing lifestyles and increase in the per capita income, the demand for floriculture has also gone up substantially. At present, it has become one of the profit making trades, owing to constant rise in the demand of flowers and its products.
- Floriculture exports from India are primarily dominated by fresh cut flowers and dried flowers.
- The various fields of revenue generation in floriculture include cut flower production, loose flower production, nursery, potted plants, seed industry, extraction of essential oils and value-added products.
- The production of loose flowers is the highest in Tamil Nadu, followed by Karnataka and Madhya

Pradesh, whereas, the production of cut flowers is the highest in West Bengal, followed by Karnataka, Odisha and Uttar Pradesh.

- Several seed companies have established production units in major flower growing states to meet the demand of flower seeds.
- Seasonal flower seed production is a established business in Punjab, Karnataka and Maharashtra.
- Some of the agri-export zones for floriculture set up by the Government of India are in Maharashtra, Sikkim, Tamil Nadu, Uttarakhand and Karnataka (APEDA).
- In terms of floricultural production and export units, south India dominates, having more than half of the total units.
- The United States, Germany, the United Kingdom, the Netherlands and the United Arab Emirates are perhaps some of the major countries, which import floricultural produce from India.

Prospects of Indian floriculture

Since time immemorial, India has a tradition of growing flowers. It is considered as a high growth industry. The export-oriented flower production has increased due to the government's liberal policies.

The scope of floriculture in India are as follows:

- Opportunities for floriculture are increasing due to various uses of flowers—for aesthetics, prayers, festivals and other occasions, and perhaps due to the increasing purchasing power of people.
- The demand for floricultural plants and their produce, such as bouquet, garland, *veni* and value-added products, like dry flowers, pot-pourie, is increasing day-by-day in various functions and celebrations.
- Strategically and geographically, our country is well located between major flower markets—Europe and East Asia.
- Export is likely to get a boost due to the development of model floricultural centres and agri-export zones created by the government.

- The availability of diverse agro-climatic conditions in the country enables to grow all flowers in one season or the other.
- The winter season is mild in India as compared to other flower producing temperate countries. This provides us with an opportunity to grow and produce flowers and seeds for export during the season when the demand is high because of Christmas, New Year, Easter, Mother's Day, Father's Day and Valentine's Day.
- Floriculture offers employment for skilled, as well as, unskilled human resources, including rural youth and women.
- Landscaping has become an integral component of urban horticulture, which apart from its aesthetic value, protects the environment, reduces air and noise pollution and promotes eco-tourism.
- Lawn establishment and maintenance have become an integral part of landscaping, which require skilled, as well as, unskilled human resources. This has become a lucrative enterprise.
- In the light of climate change, the scope of turf or lawn grasses, vertical gardening, roof gardening, etc., is on the rise.
- Increasing industrialisation and depleting agricultural land has opened avenues for the production and marketing of potted plants. It has also opened avenues for plant rentals for interior decoration in hotels, corporate houses, etc.
- Nursery industry is coming up as a flourishing enterprise, giving high returns. There is a demand for high quality flower seeds, including F1 hybrids.
- Protected and hi-tech cultivation of cut flowers has a great future. One can increase the area under intensive flower production to increase floricultural exports.
- The extraction of essential oils, natural dyes, pharmaceuticals and nutraceutical compounds from flower plants is also an important activity and is coming up as a lucrative business.

Classification of ornamental plants

Based on life span

Annuals

Plants, which complete their life cycle from seed germination to seed production in one growing season, are 'annuals'. They complete the process of life, such as seed germination, growth, flowering, seed formation and die in one growing season or year. They require replanting in every season. They are mostly grown through seeds and are commonly called 'seasonal'. Examples are China aster, coreopsis, gomphrena, marigold, petunia, tithonia, verbena, zinnia, etc.

Biennials

These are the plants that complete their seed-to- seed life cycle in two seasons or two years. Usually, most of the temperate season plants are biennial in nature as they complete vegetative growth in one season or year and flowering to seed formation in another season or year, such as amaranthus, celosia, hollyhock, pansy, snapdragon, etc. These require replanting.

Perennials

Plants that have a life cycle that is more than two years are called 'perennials'. They produce seeds or flowers every year once the bearing starts. They do not require replanting. Once planted, they flower every year. Perennials are, usually, categorised into two groups.

Woody perennials

These mostly comprise trees, shrubs and vines, which have woody stems and branches, such as *Cassia siamea*, *C. fistula*, *Peltophorum*, *Cassia biflora*, *Lawsonia alba*, *Hibiscus rosa-sinensis*, *Petrea volubilis*, *Quisquallis indica*, *Vernonia eleagniaefolia*, etc.

Herbaceous perennials

These comprise plants with soft and herbaceous (non-woody) main stalk, such as anthurium, bird of paradise, geranium, gerbera, heliconia, pelargonium, periwinkle, portulaca, perennial balsam, sweet violet, viola, etc.

Based on season of growth

Winter season annuals

Winter season annuals are hard to grow during the rigours of winter, withstanding low temperature. The seeds of annuals are sown in September–October and the seedlings are transplanted in October–November, for example, candytuft, antirrhinum, larkspur, nasturtium, pansy, petunia, phlox, sweetsultan, verbena, etc.

Summer season annuals

These are grown in the summer season and can tolerate high temperature to produce flowers. The seeds are sown in the end of February or beginning of March and seedlings are transplanted in the end of March–April, for example, cosmos, gaillardia, gomphrena, kochia, portulaca, sunflower, tithonia, zinnia, etc.

Rainy season annuals

Rainy season annuals are grown during the rainy season and can produce flowers under high humidity and rainfall as compared to other annuals. Seeds are sown in June and seedlings are transplanted in July. The example are amaranthus, balsam, celosia, cock's comb, gaillardia, etc.

Based on market value

Loose flower

Loose flowers are harvested without stalk. Examples of loose flowers are — barleria, bedding dahlia, calotropis, chrysanthemum (spray type), *chandni*, crossandra, eranthemum, gaillardia, jasmine, *kamini*, *kaner* (yellow and red), lotus, marigold, rose (fragrant *desi* type), shoe flower (hibiscus), sunflower, tuberose, water lily, etc. They are used for making *rangoli*, *gajra*, *veni*, garland, and offered for worships at home, as well as, in religious places.

Cut flower

Cut flowers are fresh flowers, flower buds or spikes harvested along with their stems attached to the flowers, length of stems being as specified to individual flowers. Examples of cut flowers are

alpinia, anthurium, antirrhinum, bird of paradise, carnation, freesia, gerbera, gladiolus, gypsophila, heliconia, iris (bulbous), lupins, narcissi, orchid, rose (improved varieties), scabiosa, statice, tuberose, watsonia, etc. They are mostly used for bouquets and vase arrangements.

Flower yielding value added product

They are used as raw material in industries for the extraction of essential oils and preparation of edible products, such as *gulkand* and rose water. They are also used for the extraction of pigments as natural colours, and as dry flowers, such as acroclinum, jasmine, marigold, rose, etc.

Based on type of plant

Herbaceous

Lilium, verbena, viola, etc.

Shrubs

Bougainvillea, jasmine, lawsonia, hamelia, nyctanthes, rose, tecoma, etc.

Trees

Gulmohar, *palash*, *amaltas*, *kadamb*, pride of India, etc.

Climbers and Creepers

Adenocalymma, *Antigonon*, Rangoon creeper, *madhulata*, petrea, thunbergia, etc.

Based on mode of propagation

Bulbous plants

Lily, narcissus, tuberose, tulip, etc.

Cormous plants

Crocus, gladiolus, tritonia, watsonia, etc.

Rhizomatous plants

Canna, hedychium, iris, lotus, etc.

Tuberous plants

Begonia, dahlia (root tuber), etc.

Practical Exercises

Activity

Identification of common flowers/ ornamental plants

Material required: Pen, pencil, practical notebook, herbarium file, etc.

Procedure

Visit a nearby flower growing farm, garden or flower market.

1. Collect the specimen of various ornamental plants or flowers.
2. Identify and list the collected flowers.
3. Maintain herbarium record or paste flower images in the practical notebook.
4. Classify flowers on the basis of life cycle, season and growth behaviour.

Check your Progress

Fill in the Blanks

1. Plants comprising soft and non-woody main stalk are known as _____ perennial.
2. Trees, shrubs and vines come under _____ perennial.
3. Those plants that complete their life cycle in one year are known as _____.
4. Plants that complete their life cycle (seed-to-seed) in two seasons or two years are known as _____ .
5. India ranks _____ in exporting floriculture products.
6. Plants grown inside a house are known as _____.
7. A _____ is an integral part of garden.
8. Nurseries are meant for multiplying and supplying the _____ materials.
9. Cut greens or green foliage are used as _____ with cut flower in flower arrangement.

Multiple Choice Questions

1. Floriculture is a branch of horticulture that deals with _____.
   (a) processing of vegetables
   (b) planting crop
   (c) production of fruits
   (d) cultivation of flowers

2. Cut flowers are harvested _____.
   (a) with stalk
   (b) with whole plant
   (c) without stalk
   (d) with leaves
3. The highest loose flower producing State is _____.
   (a) Tamil Nadu (b) Haryana
   (c) Uttar Pradesh (d) Punjab
4. The perception of beauty and study of its appreciation is _____.
   (a) aesthetic value (b) pharmaceuticals
   (c) cosmetics (d) cultivation

Subjective Questions

1. Describe the following:
   (a) Floriculture
   (b) Difference between loose flower and cut flower
   (c) Cut green
2. What are the prospects of Indian floriculture in your view?
3. Do you think lawns are important? If so, why?
4. What is indoor gardening?
5. Give any two examples of the following ornamentals:
   (a) Ornamental shrubs
   (b) Ornamental trees
   (c) Ornamental annuals
   (d) Herbaceous perennials

Match the Columns

A	B
1. Bulbous plants	(a) Begonia, dahlia
2. Cormous plants	(b) China aster, carnation
3. Rhizomatous plants	(c) Hollyhock, pansy
4. Tuberous plants	(d) C. fistula, hibiscus rosa-sinensis
5. Annuals	(e) Canna, iris, lotus
6. Biennials	(f) Crocus, gladiolus
7. Perennials	(g) Lily, tuberose, tulip

Unit 2

Nursery Management

Introduction

A nursery is a place where rooting of planting materials or germination of seeds can be obtained in a better way, under favourable growing conditions. In a nursery, seeds germinate effectively and seedlings give better stand in field. The period required for germination and establishment of seedlings can be easily utilised in a nursery and skipped in the preparation of land or harvest of previous crop in the field. This results in early growing of the crop. Flowering crops are mostly raised by seeds, cuttings, layer and grafting. In vegetatively propagated crops, root stocks are raised by seeds, or cutting. All these require care and can be grown well in a nursery under supervision.

A nursery may be established for a short term on a required site so that all planting requirements are at hand. This is called a 'temporary nursery', which is target-oriented for a particular project. Commercial nurseries are raised with a target of selling planting material with high profit margin. Such nurseries are individual establishments where quality planting material is prepared. A nursery requires almost all necessary farming inputs. An ideal nursery should have quality rooting media, skilled labour and specialised nursery structures. It involves preparation of land for

planting and its maintenance, fertility and productivity, maintenance of mother plants, requirement of various farming and specialised nursery tools, equipment and their maintenance, crop protection measures, etc.

Session 1: Nursery and its Importance

Importance of nursery

- Wastage of small and expensive hybrid seeds is reduced considerably due to better care and management.
- Germination percentage can be improved by providing ideal condition in a comparatively smaller place.
- The management of seedlings can be done in a better way with minimum care, cost and maintenance as the nursery area is small. Flowers with very small growth are difficult to grow without first raising the nursery.
- By selecting vigorous and healthy seedlings in the nursery for transplanting, better and uniform crop growth can be obtained in the main field through better survival chances.
- The duration of the crop is reduced in the main field by at least a month due to the raising of seedlings, which saves land and labour of the main field and also gives enough time for harvesting of the previous crop.
- The control of insect pests, diseases and weed is easy in a nursery.
- Nurseries offer great opportunities of employment to semi-skilled, skilled and unskilled human resources.

Types of nursery

Nurseries are classified on the basis of duration, plant produce and structure used.

On the basis of duration

Temporary nursery

This type of nursery is established for an ongoing project of landscaping, forest, hilly regions or in natural garden

in a particular season. It may also be called 'nursery on site'. As the name indicates, it exists for a short period or up to the completion of the targeted project. Temporary nursery fulfils the seasonal requirement of landscaping. Seedlings produced in a temporary nursery are according to target and utilised fully, and not for any type of sale. Seedlings are raised only for a season and as soon as the seedlings are transplanted, the role of nursery is over. Therefore, it is also called 'seasonal nursery'. There are several advantages with some underlying disadvantages of a temporary nursery. Initial investment in such a nursery is very low. It eliminates transportation, so first of all, the cost of transportation is reduced; secondly, transitional shock to the seedlings is negligible. Creation of extra infrastructure is not required. The prepared plants are according to the task and utilised completely. Wastage of seedlings due to mortality is minimum.

Permanent nursery

These nurseries are established with a view to supply planting material continuously wherever required. As the name indicates, it consists of a permanent infrastructure with availability of all required inputs. Permanent nursery may also be called 'commercial nursery', where quality planting material is produced for sale. The reputation of the nursery depends on the quality planting material produced. Permanent nursery comprises office, store, mother blocks, nursery beds, protected structures, irrigation source, electricity, transportation facilities, packing yard, manure, cattle and machinery shed. It has a record of sale and purchase, history and record of mother plants and record of produced planting material. It requires skilled workers, supervisors or managerial staff permanently. The tools and equipment required for cultivation and propagation of plants and chemicals that are necessary for raising and development of planting material is of prime importance. It is an individual enterprise and serves as a profitable source of income to the owner. Permanent nursery requires a planned outline and management. The initial capital requirement is high.

On the basis of type of plants produced

Ornamental nursery

Seedlings, root stock and scion material of ornamental plants is raised and conserved for further use. This nursery includes mother block of ornamentals, which serve for scion material in layer age, budding and grafting. Raised and flat beds of the nursery occupy seedlings of different annuals, perennials and root stocks of ornamentals. Separate block of nursery consists of vegetative and reproductive phase of bulb and tuber crops. Cuttings of different climbers and creepers are planted for rooting separately. Ornamental nursery also has many indoors and outdoor potted plants. Block of seedlings of cut flowers and loose flowers, seasonal, bonsai, climber and creepers are managed individually.

Vegetable nursery

In this nursery, planting materials, like seedlings of all vegetables, rooted cuttings (asparagus, sweet potato), seedlings raised from rhizomes (ginger) and tubers (potato), bulb (onion, garlic) for seed purposes are raised and conserved.

Fruit plant nursery

In this nursery, seedlings and cuttings of root stocks, budded plants, grafts, layers and cuttings of fruit trees are raised and conserved for further use. This nursery has mother block of different fruit crops used as scion material.

Forest nursery

Different species of trees and climbers planted in forests and used in social forestry are mostly propagated by seeds. Seedlings of big trees, like margosa, gulmohar, *amaltas*, *kanchan*, tamarind, *aonla*, prosofis, oak, eucalyptus, etc., are commonly found in a forest nursery.

On the basis of structure used in nursery

Open field nursery

These nurseries are established in open areas without any permanent structures. Usually raised, flat or

sunken seed beds are prepared. These are vulnerable to natural environmental conditions.

Hi-tech nursery

Such a nursery established under protected structures, can be successfully raised.

Thatched-roof

In this type of nursery, thatched roof is constructed over the nursery beds. This protects the seedlings from damage from extreme wind, rain, temperature or hot sun, etc. It is less costly but not very effective.

Shade-net

Such a nursery is raised under shade-net houses. To give different amount of shade based on the crop requirement, shade-nets of different colours and mesh size are used as covering material.

Poly-tunnel

The nursery is covered with plastic material to form a tunnel. It is a miniature structure, which produces greenhouse-like effect. Besides being not very expensive, it is easy to construct and dismantle. The seedlings are protected from cold, wind, storm, rain and frost. Due to modified conditions, there is better germination and plant growth.

Greenhouse/polyhouse

It is a frame covered structure with polyfilm or shade-nets so that plants can be grown under partially or completely modified environment. Such structures are provided with adequate ventilation and may have temperature and humidity controlling devices. Seedlings are raised inside the structure on raised beds, or in plug-tray, used for hardening of seedlings and tissue-cultured plants.

Nursery inputs

Plant Growth Regulators (PGRs)

It is a complex organic compound other than nutrients, which applied in minute quantities, is able to promote

or inhibit growth. The use of plant growth regulators is being enhanced to manipulate flowering, growth and yield of flowering plants.

Classes of Plant Growth Regulators

Some of the Plant Growth Regulators are as follows:

Auxins

In a plant, auxins are synthesised in the apical portion of stem and root. Auxins control growth through cell enlargement and influence developmental responses, such as apical dominance. Indole acetic acid (IAA), Indole butyric acid (IBA), Naphthalene acetic acid (NAA), 2,4-Dichlorophenoxyacetic acid (2,4-D) are some examples of auxin (Table 2.1).

Cytokinins

Cytokinins help in the transport of amino acids in plants. They promote cell division and senescence.

Gibberellins

They control cell division and elongation in plant shoots, for example, GA_3.

Ethylene

It is a gaseous hydrocarbon and known as a 'ripening hormone', for example, ethephon, ethrel.

Abscisic acid

It is, generally, considered as a 'growth inhibitor'. Because of its effects on growth inhibition or senescence, it is also involved in metabolic activities of plant viz., abscission of leaf, response to environmental stress and fruit ripening.

Application of PGR

Growth regulators are applied in very low concentrations, i.e., in parts per million (ppm). (one milligram in one litre of water gives 1 ppm solution).

Formulation of PGR

Growth regulators may be applied in powder form or paste form or as spray solution.

Table 2.1: Plant Growth Regulators application in flower crops

S. No.	Name of PGR	Crop	Concentration (ppm)	Mode of action
1.	Auxins (IAA or NAA)	• Dahlia • Orchids	>100 500	• Delays flowering • Promotes root growth
	IBA	• Balsam • Bougainvillea	5 1000–3000	• Increases shoot length • Induces rooting
	2,4-D	• Gulmohar	8000–12000	• Induces root initiation
2.	Cytokinin	• Orchids	500	• Enhances shoot growth
3.	GA3	• Antirrhinum • Chrysanthemum • Dahlia • Gladiolus • Petunia • Rose • Tuberose	25 100–400 100–150 100–200 500 100–400 100–200	• Induces early flowering • Increases plant height, internodal length and flower stalk length • Induces flowering and weight • Improves corm yield • Improves germination percentage • Improves stem length and quality • Improves bulb yield
4.	Etherel	• Gladiolus	1000	• Breaks corm dormancy
	Ethephon	• Carnation	600–800	• Promotes branching
5.	Benzyladenine	• Chrysanthemum	600–1000	• Breaks apical dominance
6.	B-Nine	• Geranium	1000–5000	• Increases adventitious roots
7.	MH	• Bougainvillea	1000–5000	• Encourages compact bushy growth
8.	TIBA	• Marigold	5–25	• Causes more branching

Practical Exercises

Activity

Visit a nursery

Material required: Pen, pencil, notebook, practical file, etc.

Procedure

1. Visit a nearby nursery and note down the following:
   - Type of nursery
   - Area of nursery
   - Site of nursery
   - Types of plant grown in nursery
   - Infrastructure of nursery — manpower, structures, tools and equipment, etc.
2. If any query, please discuss with the nursery owner.

Check your Progress

Fill in the Blanks

1. A place where seedlings or planting material is raised under controlled conditions is known as_____.
2. A type of nursery established for an ongoing project of landscaping is_____.
3. Temporary nursery is also known as _____ nursery.
4. Permanent nursery may also be called a _____ nursery.
5. Commercial nursery supplies _____ continuously, whenever required.

Multiple Choice Questions

1. Nursery raising _____overall period of the crop in the main field.
   (a) reduces (c) maximises
   (b) optimises (d) None of the above
2. Temporary nursery is _____.
   (a) for seasonal planting
   (b) nursery on site
   (c) for planting in forest and hilly regions
   (d) All of the above
3. Nursery established under protected structure is known as _____.
   (a) hi-tech nursery
   (b) technical nursery
   (c) low-cost nursery
   (d) All of the above
4. Cytokinins are hormones that help in _____.
   (a) cell division
   (c) cell elongation
   (b) ripening
   (d) cell enlargement
5. Complex organic compounds applied in minute quantity to promote or inhibit the growth of the plant are _____.
   (a) PGRs (c) organic fertiliser
   (b) micro-elements (d) macro-elements

Subjective Questions

1. Do you think nurseries are important?
2. What are the different kinds of nurseries? Describe the benefits of one of them.
3. Why are Plant Growth Regulators used?

Match the Columns

A	B
1. Auxins	(a) Ethephon
2. Cytokinins	(b) GA3
3. Gibberellins	(c) Kinetin
4. Ethylene	(d) NAA

Session 2: Growing Media and Nursery Bed Preparation

Growing medium

The material in which plants grow in a pot is known as potting material and is commonly called the 'growing medium' or 'potting medium'. The selection of the type of potting material is important as the growth of plants completely depends on it. The main function of the growing medium is to supply nutrients, air and water to the roots of the growing plants. It supports the plant physically and holds it in an upright position and allows growth against the gravitational force. For the above two functions, it is necessary that the medium facilitates the growth of root within it. It is, therefore, desirable that an ideal growing medium is porous and allows aeration. It must have a good water-holding capacity so that frequent irrigation is not required. It should support and favour the growth of the plant and must be free from toxins, ailments and insect pests. The growing medium should respond well to the application of manures and fertilisers, as well as, pesticides. It should be light in weight, easily available and have a suitable pH level. The chemical composition, as well as, physical structure of the medium favours the growth of the plant.

Types of growing media

Different types of growing media are used for the propagation of plants.

Garden soil

Light and sandy soils are ideal growing media, while loamy, silt or clayey soils are not preferred due to poor aeration and stickiness. The soil contains both organic and inorganic matters. Soil is a common, universal, easily available and comparatively cheaper medium used in a nursery.

Sand

Large particle size makes this medium more porous, aerated and well-drained. The water-holding capacity of this medium decreases with an increase in the size of particle. The usual size of sand is 0.05–2.0 mm. Quartz sand is a useful growing medium but it lacks in nutrient content. It is relatively inexpensive and heavy. Generally, it is mixed with soil and used as a well-drained porous medium.

Compost

It is decomposed organic matter used with soil. Dropped leaves, twigs, grass clippings, cattle feed waste, and farm animal excreta are some of the common ingredients that are used for the preparation of compost. All these are allowed to decompose in a pit prepared at the farm. Compost contains major and minor nutrients that plants need for growth.

Fig. 2.1: Sphagnum moss

Sphagnum moss

It has excellent water-holding capacity and can hold water many times its weight. It is commonly used as rooting medium in air layering. It is comparatively costly and not available easily (Fig. 2.1).

Fig. 2.2: Peat

Peat

Peat consists of residues from a marsh swamp. It comprises some organic nitrogen. It helps in fast vegetative growth. It is commonly used for growing newly rooted cuttings or newly germinated seeds (Fig. 2.2).

Fig. 2.3: Coir peat

Coir peat

It is obtained from coir fibre dust. It is acidic in nature and has a pH of about 5.0. It has a high water retention capacity (Fig. 2.3).

Vermiculite

It is chemically hydrated magnesium aluminium iron silicate. It is produced by heat treatment of

mica. It is porous and light in weight. It has a good water-holding capacity (Fig. 2.4).

Fig. 2.4: Vermiculite

Perlite

It is a natural mineral of volcanic origin, which is light weight. The pH is usually neutral to slightly alkaline (Fig. 2.5).

Saw dust

These are the by-products of saw mills. It is easily available and cheap. It is poor in nutrient content but can be used after the addition of nitrogen (Fig. 2.6).

Fig. 2.5: Perlite

Fig. 2.6: Saw dust

Potting mixture

For potting of rooted cutting and young seedlings: 1 or 2 part sand + 1 part loamy soil + 1 part peat moss or leaf mould

For potting general container grown nursery stock: 2 part sand + 4 part loamy soil + 2 part peat moss or leaf mould + 1 part well rotted FYM

Nursery bed and its importance

A nursery bed is a well-prepared piece of land used for raising seedlings or rooting planting material. It acts as a temporary place for the development of young seedlings. Seedlings are transplanted at a definite stage of growth from nursery bed to the main field. Nursery bed is a small plot of 1-metre width where the seeds are sown closely width-wise.

There are several advantages of raising the seedlings in the nursery bed.

(i) Due to the small size of a plot, it becomes convenient to look after the germinated seeds and the coming seedlings.
(ii) Favourable conditions can be provided efficiently in a relatively small area.
(iii) Precautionary measures against diseases and pests can be undertaken easily.
(iv) Raised bed avoids water stagnation and provides aeration to roots, enabling their fast growth and better establishment of seedlings.
(v) Due to intense care, the percentage of seed germination improves.
(vi) Seed wastage due to washing away and wrong placement is checked.
(vii) The time period required for the preparation of seedlings in a nursery proves to be a bonus for the preparation of the field or late harvesting of the previous crop.

Site selection for nursery

Location

Ideally, a nursery, should be located in a pollution-free environment. It should be away from brick kilns, smoke emitting industries and heavy traffics. Non-concrete roads deposit a lot of dust on plants. It must be ensured that adequate sunlight is available in the nursery but the plants must be protected against severe heat.

Topography of land

The topography of land at the nursery site must be even to facilitate intercultural operations. If it is undulating, it must be levelled. In hilly areas, the land may be divided into levelled terraces.

Soil

It must be preferably loam or sandy loam with large quantity of organic matter. The pH of the soil needs to be slightly acidic to neutral and must not be alkaline or saline. The soil should have good drainage and proper water retention capacity. Aerated, porous, fertile and productive soils are preferable.

Water

Quality water in adequate quantity must be available at the site for irrigation. The nursery must be near to a natural source of water. The water should be free from harmful salts, toxins or salinity.

Drainage

The nursery site should be free from waterlogging. Water must not be allowed to stagnate for a long duration as it affects gaseous exchange and leads to poor development of roots. Proper drainage facilities must be provided at the site.

Transportation and marketing

The nursery site should be connected with approach roads or railway. It would be convenient to locate the nursery near a market. If the market is far, it will result in high transportation cost and the plants are likely to be damaged.

Labour

As nursery work is labour-intensive and requires skilled labour, the availability of skilled labour in the vicinity is important.

Protection from wind and animals

The nursery must be protected by a strong fencing to avoid grazing animals and thieves. Suitable plants are planted as windbreak in the south-west direction to avoid losses from strong wind.

Preparation of nursery bed

Nursery beds can be prepared in three ways.

Sunken beds

This type of nursery bed is prepared in dry and windy areas. As the name suggests, a sunk of 10–15 cm deep is prepared from the ground level. Sunk facilitates the deposition of irrigation water or rainwater for longer time. In areas facing water scarcity or shortage, this type of bed helps to conserve moisture. Sunken bed

provides protection to the seedlings during heavy winds (Fig. 2.7).

Flat beds

These are prepared on the surface of land to the field level. Bunds are created all round to stop the irrigation water inside. These are made in nursery for raising seedlings during summer and winter season. In rainy season, water may be stagnated and cause rotting of seedlings. Sandy loam or friable soils are preferred for the preparation of flat bed. Flat bed is one-metre-wide, and its length is according to the length of the slope. Water channels run in between providing irrigation water.

Preparation of flat bed

Mark an area for the preparation of a flat bed. The surface of the marked bed is dug off. Make it fine and loose. Manure, FYM or compost is incorporated according to the size of the bed. Some pesticide, like phorate 10D, is also added to avoid termites. Seeds after treatment with suitable fungicides, generally, thiram @3g/kg, are sown to check soil-borne infections.

Raised beds

In this type of a nursery bed, soil is raised to a height of 15–20 cm above the surface. Hence, it is called 'raised bed'. Layers of soil are placed over the surface of field so that it forms a bedding of soil. The raised height facilitates the drainage of water and provides aeration to the roots of developing seedlings. These beds are preferred during the rainy season to avoid water stagnation. Raised beds are also prepared in soil with poor drainage as height improves both aeration and drainage. Raised bed minimises the risk of damping-off and increases the chances of survival of seedlings during the rainy season.

Preparation of raised bed

The surface of the soil is dug out and brought to fine tilth. Then, the soil all around the bed is pulled over to raise the surface. This automatically creates a trench around the bed, which is later used for irrigating the

bed. Manure and fertilisers are added at this time. These beds are also enclosed with bunds. The width of the bed is one metre to facilitate intercultural operations. Raised beds are about 10–12 cm above the ground level and the length may vary according to the slope of soil. Spacing of 30–50 cm is kept between two rows of the bed to facilitate intercultural operations. Treated seeds are sown width-wise in rows or sometimes by broadcasting method. Initially, these beds are watered with sprinkling water or using a watering can, so that the seeds sown are not dispersed. Once the seedlings are well-rooted and reach the ground level, the bed can be irrigated through trenches of the bed attached.

Precautions to be taken during preparation of nursery beds

(i) Nursery beds are, generally, used to germinate the seeds sown or for rooting the cuttings planted in it. Besides nutrition, moisture and aeration are important factors that affect the growth of seedlings.

(ii) Nursery bed should be prepared in fertile soil rich in organic matter content with good drainage and aeration. Soil having more water retention capacity does not need frequent irrigation.

(iii) Excess of irrigation in sunken or flat bed may lead to rotting of seeds, seedlings and damping-off incidence. Watering of the bed depends on the type of soil. Sandy soils need frequent watering.

(iv) Soil-borne infections of nematodes, insects pests and pathogens may be avoided by treating the soil.

(v) Generally, the width should not be more than one metre and the length should be according to the slope of the soil so that when irrigated water reaches each corner of the bed, the whole bed gets irrigated.

(vi) Seedlings are tender and succulents and are prone to heat shock, so the beds should be prepared in the site receiving partial shade. In tropical and subtropical India, direct sunlight facing site should be avoided.

Application of manures and fertilisers

Manures

It releases nutrients gradually. When applied, manures are likely to fulfill the leached amount of nutrients from the soil over a period of time. Besides this, it improves soil texture, which improves drainage and aeration. It is, therefore, recommended to thoroughly mix rotten Farm Yard Manure (FYM) at the time of land preparation. During the preparation of nursery beds, the soil is thoroughly mixed with 5–10 kg of rotten FYM per square metre area.

Fertilisers

Basal application

Application of fertiliser at the time of nursery bed preparation and/or at sowing of seeds is called 'basal application' or 'basal dressing'. In this method, fertilisers are spread uniformly across the nursery bed and mixed with soil. This method is suitable for phosphatic and potassic fertilisers.

Top dressing

Broadcasting of fertilisers, particularly nitrogenous fertilisers, in readily available form to growing plants in standing crop is called 'top dressing'.

Foliar feeding

It is another method of fertiliser application to nursery crops, particularly for vegetable and flowering plants. Only nutrients, like nitrogen, or micronutrients can be applied through foliar application. If a crop suffers due to deficiency of micronutrients (Fe, Mn, Zn and Cu) deficiency symptoms appear on plants, it can be corrected by foliar feeding. It requires certain

precautions, like low concentration of nutrients and availability of sufficient foliage.

Protection of seedlings

Soil treatment

Soil or any planting medium used for nursery may be contaminated by pests. The presence of pests in the medium causes huge losses to the crop in a nursery or infection may be carried to the field through seedlings or adhering medium on the roots. It is, therefore, advocated that the medium used for the nursery must be free from infections or infestations. Different methods adopted for soil treatment are as follows:

Solarisation of soil

In this method, temperature of the soil or medium is raised so high (47° C and above) that infested or incubated pests get controlled or destroyed. It is a physical method that utilises the energy of the Sun to increase the temperature. It is, generally, followed in tropical and subtropical India, where the Sun is too hot during summers.

Procedure

First of all, dig out the soil at the site where the beds are to be prepared. Remove stones, pebbles and weeds. Crush the clods and bring it to fine tilth. Wet soil conducts heat better than dry soil, so irrigate the area thoroughly. Cover the site with a black polythene film of 200 gauge thick and make the covering airtight by covering the margins with compressed wet mud. This rases the temperature of the soil upto 47° C or above. Within 5–6 weeks, the soil is free from any infection or infestation. A nursery bed may be prepared at the treated site or soil may be used for filling pots or polybags.

Steam treatment

This method is followed in advanced countries and is not common in India. Hot steam is diffused in the soil to control soil-borne pests. The nursery bed is covered with a polythene sheet to make it airtight. Hot steam is supplied mechanically for at least 4–6 hours continuously to kill the pests.

Chemical treatment

Formalin

Commercial formaldehyde is available in liquid form. It is an effective fumigant, highly toxic to organisms of plant and animal origin. Sterilisation of the soil of nursery bed is carried out at a dilution of 0.25%. Beds of desired size are prepared and diluted solution of formalin is drenched at the rate 4–5 litres per sq m area. The solution percolates up to a depth of 15–20 cm. The poisonous fumes penetrate the soil and make it germ-free. The emitting fumes can be retained at the site for 48 hours by covering the treated area with a thick polythene sheet. Remove the cover after 48 hours of treatment. The bed is kept open for 7–8 days prior to seed sowing. Immense precaution is needed while application. Gloves, masks and goggles must be worn by an applicator to avoid direct contact with fumes.

Fungicides

In nurseries, soil-borne pathogens are responsible for diseases, like wilt, rots and damping-off. Inoculums in the soil may be eliminated by adding or drenching fungicides into the soil. Fungicides, like *captan* and *carbendazim*, can be applied to the soil by either method — dry application at the rate 5g per sq m or drenching 4–5 litre of 2.5–3% solution of fungicides to control soil-borne pathogens.

Insecticides

Larvae of many insect pests, inhabiting soil may be a severe problem to nursery plants. These pests can be checked by the application of insecticides in the soil.

Biological method (bio-agents)

Certain biological agents, like *Trichoderma spp.*, are found effective against wilt causing and rotting fungi present in the soil and *Pseudomonas* control fruit or stem rot. These bio-agents are used at the rate 10–25g/sq m and are mixed well in the soil while preparing the beds. Seeds should be sown 2–3 days after the application of bio-agents.

Seed treatment

Seed treatment with fungicides has been found to be effective against seed-borne, as well as, soil-borne pathogens. Fungicides, such as *bavistin* or *thiram*, are applied at the rate of 2.5–3 g/kg seed not only to prevent seed-borne infections but also to provide protection against soil-borne infections.

Practical Exercises

Activity 1

Demonstrate the preparation of a raised bed.

Material required: Measuring tape, spade, garden rack, watering can, seeds, etc.

Procedure

1. Measure the area of bed to be prepared and mark with the help of stake or lime.
2. Surface soil of the marked area is dug out and brought to fine tilth.
3. Weed and plant residues are collected with the help of garden rack.
4. Soil around the bed is pulled over to raise the height to 15–20 cm.
5. The width of the bed is one metre to facilitate intercultural operations.
6. Spacing of 30–50 cm is kept between two rows of the bed.
7. Treated seeds are sown width-wise in rows or broadcast.
8. Irrigate the bed with a rośe watering cane.

Activity 2

Demonstrate soil treatment by solarisation.

Material required: Spade, garden rack, polythene film of 200 guage, etc.

Procedure

1. First dig out the soil at the site where the beds are to be prepared.
2. Remove stones, pebbles and clumps of weeds.
3. Crush the clods and bring it to a fine tilth.

4. Irrigate the bed thoroughly.
5. Cover the bed with a 200 guage thick black polythene film.
6. Make the covering airtight by covering the margins with compressed wet mud.
7. This raises the temperature of the soil up to 47° C or above.
8. After 5–6 weeks, observe the weed population.

Check your Progress

Fill in the Blanks

1. In water scarcity or shortages, _____ bed helps to conserve moisture.
2. Level beds are commonly known as _____.
3. In raised bed preparation, the soil is raised upto a height of _____ cm.
4. Seed treatment prevents _____ and _____ infections.
5. Ideal soil types as growing media are _____ and _____.
6. Clayey soil is not a desirable medium due to _____ and _____.

Multiple Choice Questions

1. Micro-nutrients can be applied through _____.
   (a) deep placement
   (b) top dressing
   (c) foliar feeding
   (d) basal dressing
2. The usual size of sand is from _____.
   (a) 2.0 to 2.5 mm
   (b) 0.05 to 2.0 mm
   (c) 2.5 to 3.0 mm
   (d) 3.0 to 3.5 mm
3. Dilution of formalin applied for the sterilisation of soil in nursery is _____.
   (a) 0.25% (b) 2.50%
   (c) 25.0% (d) 0.025%
4. _____, a biological agent, is effective against soil-borne fungi.
   (a) *Fusarium spp.*
   (b) *Trichoderma spp.*
   (c) *Sclerotinia spp.*
   (d) *Trichogramma spp.*

Subjective Questions

1. What is a growing medium? List its types.
2. Why do you think nursery beds are required?
3. Describe the different methods of fertiliser application in a nursery.
4. What is soil solarisation?

Match the Columns

A	B
1. Organic matter	(a) Sphagnum moss
2. Micro-nutrient	(b) Compost
3. Good water-holding capacity	(c) Peat
4. Residue from marsh swamp	(d) Fe, Mn, Zn
5. Hydrated magnesium aluminum	(e) Soil solarisation
6. Volcanic origin	(f) Vermiculite
7. Control of soil-borne pests	(g) Perlite

SESSION 3: SEED SOWING AND PLANTING MATERIAL

Methods of seed sowing

Broadcasting

After the preparation of a nursery, spread the seeds on nursery beds and cover them with finely sieved rotten FYM or compost. This method has some disadvantages, as seeds cannot be placed at equal distance. This might require a large number of seeds in comparison to other methods of seed sowing.

Line sowing (shallow trenches on bed)

It is the best method of sowing seeds in a nursery. Sowing in lines improves germination and quality of seedlings. In this method, each seed gets independent space, and hence, grows healthy and vigorously. In this method, the diseased seedlings and weeds can be managed easily.

Procedure

On a levelled bed, shallow trench of certain depths are made with the help of a stick width-wise, with the

required spacing. This depends on the size of the seeds. Small seeds are sown at shallow depth and at low spacing between rows and vice-versa. Seeds are, generally, sown at a depth of 3–4 times of its diameter. They are placed singly at equidistant points in rows. Small seeds are mixed with sand for even distribution. The trenches are, then, covered with fine soil. The beds require light irrigation from sowing till transplanting by means of a sprinkler or a water can. Mulching of seed beds by polyethylene sheet, paddy straw, etc., helps in quick and uniform germination of seeds. Mulches should be removed immediately after the germination of seeds.

Fig. 2.7: Seed sowing in pro-trays

Seed sowing in plug trays

High value and hybrid seeds are preferred to be sown in plug trays (pro-trays) instead of open field nursery beds. Pro-trays are made of soft plastic having shallow plugs. These plugs are filled with planting medium. Coco peat, a by-product of the coir industry having a high water-holding capacity, is commonly used as a medium in pro-trays (Fig. 2.7).

Procedure

Small depressions (0.5 cm) are made at the centre of the plugs with fingertips for the sowing of seeds. The seeds are placed in the depressions and covered. Water is sprinkled by a water can to maintain moisture.

Rooting of cuttings

Many ornamental plants are commercially propagated by asexual means of reproduction. Planting of rooted stem cutting (*duranta*, croton, *acalefa*, etc.), leaves (*bryophyllum*) or roots (begonia) are important methods in most commercial ornamental crops. Some plants are propagated by grafting and budding, and root stocks needed for this are raised by planting the stem cutting. So, rooting of cuttings is another important method involved in vegetative propagation of

ornamental plants. Cuttings are planted on raised beds, flat beds or on the side of ridges, for rooting. For budding and grafting purpose, poly bags of requisite sizes are used for rooting of root stock. Cuttings treated with hormones induce fast rooting. Sand or sandy loam is supposed to be a good rooting medium due to adequate aeration and drainage.

Potting, depotting and repotting

Potting

It refers to the transferring of plants from seed bed or polyethelene bags to pots containing potting mixture. Potting of plants involves various steps.

(i) Selection of the pot
(ii) Filling the pot with potting mixture
(iii) Placing the plant
(iv) Watering and staking the plant
(v) Placement of the pot

Pots

Ornamental plants are grown in a variety of pots, depending on the choice and availability. Clay, cement, ceramic, plastic and other kinds of pots are used for growing house plants. However, clay pots are most popular, easily available, highly porous and cheaper. Selection of the appropriate size of pots is significant. The size of the plant and its growth habit are to be considered before selecting a pot. For specimen plant display, the pot size should be of at least 30 cm diameter.

Potting mixture

An effective potting mixture must be light in weight and have good water-holding capacity. It allows drainage and helps in supplying adequate nutrition to plants. It must be ensured that the mixture is free of insect pests and diseases. For ferns and bulbous plants, the medium needs to be highly porous, comprising coarse sand, light garden soil and leaf mould. Neem cake and bonemeal may also be used in small quantities as nutrients.

Procedure

(i) Filling of pot

Selection of a pot is made according to the size and growing habit of a plant to be potted. Drainage hole at the base is made to ensure the drainage of excess water. The drainage hole is covered with pieces of earthen tile so that the rooting medium does not flow out with water. Large crocks of 3–5 cm size should be placed at the bottom of the pot to avoid clogging of the drainage hole. A thick layer of coarse sand is placed over it, and finally, the remaining pot is filled with the potting mixture. The pot must have 2.5 cm space from the brim for holding water.

Fig. 2.8: A potted plant

(ii) Planting

A healthy rooted cutting or a plant with well-established root intake is carefully dug out from the nursery bed. It is, then, placed with the root ball of soil in the centre of the potting mixture. Fill the pot with the potting mixture all round the ball of soil. Press the mixture around the stem firmly and make it compact. Potting of deciduous house plants is done in February–March, whereas evergreen plants in July–August (Fig. 2.8).

Precautions

- Care must be taken that the root ball of plant is not pressed too hard as it will break and damage the roots.
- Water the plant gently with a sprinkler can, immediately after planting.
- Place the potted plant in a cool shady place for settlement.
- Stake the plant with a bamboo stick, if the stem is long or weak.

Depotting

It is the removal of a plant from a pot for planting on ground soil, bed or in another pot. As roots are sensitive and prone to injuries, care needs to be taken while depotting a plant. It is better to depot the plant along with the soil attached to the root system. This soil, if needed, can be removed carefully after depotting.

Fig. 2.9: A depotted plant

Procedure

The pot must be watered before depotting. The pot is lifted by one hand, the palm of the other hand spread over the top of the soil holding the stem between the second and third finger, and the thumb along the side of the pot. The pot is then turned upside down. If necessary, a gentle tap is given on the rim of the inverted pot against a solid base or on the edge of bench to loosen the earth ball. The whole earth ball, with intertwining roots of the plant, will come out as a single piece and kept outside carefully. Before transferring the plant in a new pot, the lower old and finer roots along with some old potting mixture are removed (Fig. 2.9).

Repotting

It is transferring or transplanting a plant from one pot to another. It is the planting of a depotted plant into another pot. Repotting is done with the following objectives:

(i) Changing the existing small old pot or exhausted potting mixture to a new one.

(ii) For healthier growth of house plants, repotting and transplanting of established plants is done once in a year.

(iii) Repotting facilitates pruning of overgrown roots, which in turn ensures better survival of the plant.

(iv) Bigger size of the pot provides a larger space for root development.

Fig. 2.10: Plant ready for repotting

Procedure

Depending upon the plant type, repotting is done in February–March or just before the onset of monsoon. Cut the decayed, dead, dried or twisted roots neatly with sharp secateurs (see Fig. 3.6). The excess and old soil is gently removed from all round. The pot is filled with fresh potting mixture, and then, watering is done. Place the plant in a new pot at the same depth in the soil at which it was in the old pot.

Nursery plants: Care and maintenance

Plant handling

Nursery plants need care and maintenance when raised from root stock or by tissue culture technique. It is important to provide nursery plants with suitable conditions to ensure their growth and development. The following activities have been executed for the production of good quality planting material.

Shading

To protect the young plant in the nursery from intense heat and heavy rains, shade-nets or polythene nets are used.

Thinning

It is a way of regulating plant population in rows and lines. During this operation, unhealthy, weak, diseased and damaged plants are pulled out to allow healthy plants to grow. It is normally performed when seedlings form few true leaves. It allows sunlight and air to reach each and every plant.

Watering

The nursery bed must be irrigated with the help of a water can. After the plants are well-established, watering should be done as per the requirement of the plants.

Weeding

Weeds compete for nutrients and soil water, which results in poor quality seedling growth. They also

prevent air circulation and may harbour insects and disease-carrying organisms, and hence, nursery beds should be free from weeds. Hand weeding or hand hoeing is the most common practice to remove weeds on emergence. Pre-emergence herbicides can also be sprayed on the nursery beds as basal dressing soon after seed sowing to control weeds.

Hardening of plants in nursery

Hardening of seedlings is nothing but withholding of water to nursery beds for few days before removing them for transplanting. Hardening of seedlings is necessary to prepare them for withstanding transplanting shock. It is also practised in situations where preparation of land is delayed and the seedlings become over-sized.

Table 2.2: Common insect pests and diseases in a nursery

Diseases and pests	Characteristics and symptoms	Control
Damping-off	Rotting of seedlings at collar portion and collapse at later stage	Soil sterilisation with formalin 2%, Copper oxychloride 2g/l drench, or *Carbendazim* 2g/l
Leaf spot	Small to big black or brown-coloured spots on leaves	Spraying of mancozeb 3g/l
Leaf miner	Leaf mining insect that produces serpentine (snake-like) white shining lines on leaves	*Triazophos* 0.25 ml/l
Aphids	Small green, brown or black sap sucking insects, which secrete honey dew that attracts ants and sooty mould	*Dimethoate* 2 ml/l Neem oil 2–4 ml/l
Thrips	Tiny black or yellow-coloured sap sucking insects, which infest young portions of plants and flowers	*Spinosad* 0.2 ml/l *Dimethoate* 2 ml/l Neem oil 2–4 ml/l

Practical Exercises

Activity 1

Demonstrate potting of a plant.

Material required: Pot, potting mixture, crocks, plant, root shear, etc.

Procedure

Filling of pot

1. Select a suitable pot considering the plant to be potted.
2. Drainage hole is covered with pieces of earthen tile.
3. A thick layer of coarse sand is placed over it.
4. The remaining portion of the pot is filled with a potting mixture.
5. The pot should have 2.5 cm space from the brim for holding water.

Planting

1. A healthy rooted cutting or a plant with well-established roots is carefully dug out from a nursery bed.
2. The plant is placed with the root ball of soil in the centre of the potting mixture.
3. Fill the pot with the potting mixture all round the ball of the soil.
4. Press the mixture around the stem firmly and make it compact.
5. Irrigate the pot immediately after planting.

Activity 2

Demonstrate depotting of a plant.

Material required: Potted plant, root shear, etc.

Procedure

1. Before depotting, the plant must be watered in excess and water is allowed to settle down.
2. Without damaging, carefully remove the plant from the pot.
3. The ball of the root with soil around it comes out of the pot.
4. The plant slipped off is held in the hand, and then, it is made upright.
5. Excess soil is removed without injuring the root system, and then, used for further planting.

Check your Progress

Fill in the Blanks

1. The best method of sowing seed in a nursery is _____.
2. High value annual seeds are preferred to be sown in _____.
3. An ideal potting medium should have good _____capacity.
4. A common and serious disease of a seedling at the nursery stage is known as_____.
5. Rooted stem or roots cutting commercially are an important method of _____.
6. Transferring a plant from one pot to another is termed as _____.

Multiple Choice Questions

1. Seeds are, generally, sown at a depth of 3–4 times of its _____.
   (a) radius (b) diameter
   (c) length (d) width
2. Potting mixture should _____.
   (a) supply adequate nutrition
   (b) have good drainage
   (c) have good water-holding capacity
   (d) All of the above
3. Damping-off is, generally, favoured by _____.
   (a) high sunlight
   (b) high temperature
   (c) low temperature
   (d) high humidity
4. Transplanting from one pot to another is termed as _____.
   (a) depotting (b) potting
   (c) repotting (d) transplanting

Subjective Questions

1. What are the different methods of seed sowing?
2. How are seeds sown in plug trays?
3. What is potting? Demonstrate the method of potting.
4. Explain the hardening of plants in a nursery.
5. Describe the common nursery insect pests and diseases. How can they be controlled?

Match the Columns

A	B
1. Nursery insect pests	(a) Thinning
2. Seed treatment	(b) Acalefa
3. Regulating plant population	(c) Thrip
4. Stem cutting	(d) Damping-off

Unit 3

Tools and Equipment

Introduction

With the introduction of modern technology in agriculture, and innovative research and development of various machines and tools, flower cultivation has become easier and more profitable than in the past. A cultivator, usually, adopts mechanical farming due to several factors, like uncertainty of weather, unavailability of skilled labour and time constraints. Mechanised farming, thus, helps in completing tasks in less time, saves excessive cost of labour, and is available at all times. Various advanced tools and equipment are now in practice, which eases the cultivation of various crops.

Session 1: Implements used for Preparation of Land

Plough

Mouldboard plough

This is made of carbon steel or steel alloy, the base of which is at the right angle triangle. The size of the mouldboard plough is measured by the width of the furrow that is opened by the plough. Generally, it can

open a furrow of about 20 cm and above. It throws the furrow slices only on one side.

Disc plough

It consists of moving circular steel discs of varying sizes. The size of discs includes its diameter and thickness. Discs in different ploughs used are 50–90 cm in diameter. Discs cut, turn and break furrow slices. These can work well in sticky soil, as well as, in very hard and dry soil. It is much heavier and leaves the soil rough and cloddy.

Sub-soil single arm plough (*Patashi* plough)

This plough is useful for heavy soils. It consists of a single adjustable arm having shears at the base and breaks the hard pan developed below the soil surface. It improves drainage in water stagnant soils. It can be inserted up to 50 cm deep in the soil and is most suitable for making a trench of 5–7 cm wide.

Fig. 3.1: Disc harrows

Harrows

These are used for the preparation of finer soil by breaking clods, cutting weeds, pulverising the soil surface during field preparation. The harrows may be disc, spike, spring or blade types (Fig. 3.1).

Plank

It is a heavy wooden log, generally, used for compacting and levelling used for seed bed and field preparation for sowing the seeds. Planks are also used immediately after sowing the seeds to ensure proper covering of seeds with soil. It is also used for levelling the soil after ploughing.

Fig. 3.2: Cultivator

Cultivator

A cultivator is used to stir and loosen the soil, breaking the clods and destroying the weeds. The cultivator performs intermediary ploughing and harrowing. It also maintains a good tilth, adequate aeration, prevents run-off, and evaporation losses. Cultivators may be shovel, disc and blade types. Tine and spike cultivators are used to tilth the soil (Fig. 3.2).

Practical Exercises

Activity

Identify the implements used for land preparation

Material required: Practical notebook, pencil, pen, implements, etc.

Procedure

Write the following information

1. Identify different types of implement.
2. Write the names of the implements.
3. Describe the use of implements.
4. Draw a diagram and show the different parts of implements.

Check your Progress

Fill in the Blanks

1. The equipment used for turning over the soil or cutting furrows is called _____.
2. Mouldboard plough can open a furrow of about _____ cm and above.
3. _____ plough works well in sticky soil.
4. Sub-soil single arm plough can be inserted up to _____ cm deep in the soil.
5. Cultivator is an implement that performs _____ and _____.

Multiple Choice Questions

1. Cultivator helps to maintain good _____.
   (a) tillage (b) tilth
   (c) landscaping (d) fertility
2. An implement used for the preparation of finer soil by breaking clods is called _____.
   (a) harrow (b) plough
   (c) level board (d) rotavator
3. An implement used for levelling the field is called _____.
   (a) harrow (b) cultivator
   (c) rotavator (d) plank

Subjective Questions

1. Describe various types of implements used for field preparation.
2. Write in brief about the following:
   (i) Harrow
   (ii) Cultivator

Match the Columns

A	B
1. Mouldboard plough	(a) Disc and spike type
2. Plank	(b) Loosening the soil
3. Disc ploughs	(c) 50 cm deep
4. Single arm plough	(d) 50–90 cm in diameter
5. Cultivator	(e) Levelling
6. Harrowing	(f) 20 cm and above

Session 2: Other Tools and Equipment

For carrying out various horticultural operations, one needs different kinds of tools and equipment, such as hand cultivator, harrow, spade, secateurs, hand trowel, garden fork, sprinklers, rake, pruning saw, spray pumps, grass shear, budding and grafting knives, etc. These tools and equipment can be categorised as hand tools and power equipment. Hand tools are less expensive than power equipment, often serve multiple uses, and are easier to be used in small spaces. These tools and equipment help one to carry out day-to-day farm operations efficiently, easily, timely and economically.

Bill hook

Bill hook has single or double cutting edges. It is a hook-shaped tool consisting of a curved blade made of high carbon steel and manganese steel, attached to a wooden or plastic handle. It is commonly used for cutting big branches or to remove the old and dead branches from a tree (Fig. 3.3).

Fig. 3.3: Bill hook

Budding-cum-grafting knife

A budding-cum-grafting knife is a combination of two knives used for budding and grafting operation. It consists of two blades, one for budding and another for grafting. These blades are fixed to the ends of the handle. Both the blades are made from high carbon or alloy steel and are accommodated in one handle. Both the blades are foldable into the handle. The length of working blade may be 6.5–7.5 cm and width 1.5 cm (Fig. 3.4).

Fig. 3.4: Budding-cum-grafting knife

Slashing and pruning knives

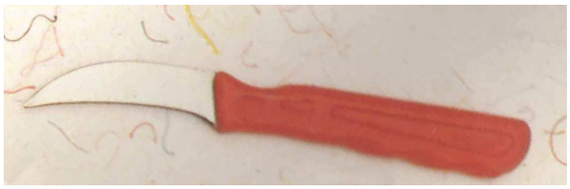

Fig. 3.5: Pruning knife

These knives are used to remove unwanted twigs or branches of a plant or tree. Such a knife is made up of a tang joined rigidly to the handle and a blade. One end of the blade is hooked or curved in order to cut or slash the small branches or twigs of a plant by pulling action. The blade is made of high carbon or alloy steel. The handle is made of good quality wood or plastic (Fig. 3.5).

Secateurs

Fig. 3.6: Secateur

These are meant for cutting the branches, de-shooting, disbudding, cutting of scion sticks, defoliation of leaves from the sticks and topping off of small trees, etc. These are also useful in pruning off pencil thick branches and making of cuttings for propagation (Fig. 3.6).

Grass shear

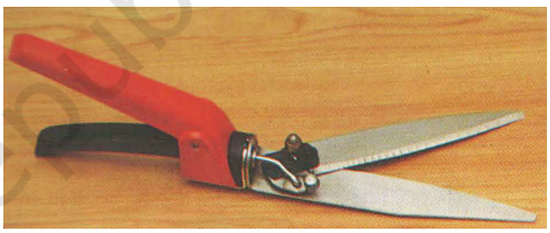

Fig. 3.7: Clipper or grass shear

Grass shear in various types are used for the maintenance of lawns. A grass shear is used for trimming and side dressing of the lawn. The important parts are cutting blades made of high carbon steel or alloy steel. The blades are sharpened at the cutting edges. The length of the blade varies from 15–20 cm (Fig. 3.7).

Hedge shear

Fig. 3.8: Hedge shear

It is used for trimming, pruning and cutting of hedges and shrubs in the desired shape. It consists of two blades with tangs. The size of the shear is according to the size of the blades varying from 15–30 cm in length and 0.8 cm thickness (Fig. 3.8).

Spade

Fig. 3.9: Spade

It is made up of cast iron and is used for digging or turning over the soil, making bunds in the field, and to prepare irrigation channels, etc. (Fig. 3.9).

Fig. 3.10: Rakes

Rake

It is used for breaking the soil surface, removing stubbles, small stones and collecting weeds (Fig. 3.10).

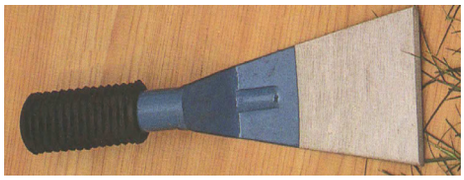

Fig. 3.11: Khurpi

Khurpi

It is made up of cast iron having a wooden handle on one side end. It is meant for weeding, lifting of seedlings and plants in the nursery, for transplanting the plants in pots and field, and for performing various other operations (Fig. 3.11).

Fig. 3.12: Sprayer

Sprayer

It is used for spraying insecticides, fungicides, herbicides, fertilisers and various other chemicals in the field. Different types of sprayers are available in the market as per the requirement (Fig. 3.12).

Fig. 3.13: Watering can

Watering can

It is used for watering seed beds, nursery beds and potted plants to avoid washing of the soil and damage to young seedlings (Fig. 3.13).

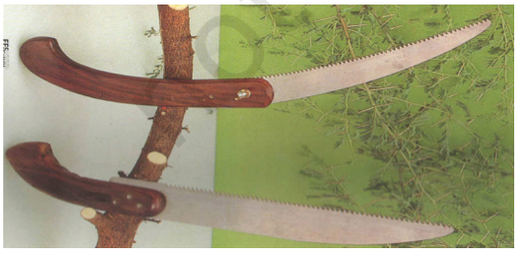

Fig. 3.14: Pruning saw

Pruning saw

It is used to cut thicker branches of plants (Fig. 3.14).

Fig. 3.15: Wheelbarrow

Wheelbarrow

It can be used to move heavy things from one place to another, and also to hold garden trash (Fig. 3.15).

Hand cultivator

It is used for altering and loosening the soil without damaging the roots in the garden nursery (Fig. 3.16).

Fig. 3.16: Hand cultivator

Tree pruner

It is used for pruning shoots of trees, which are beyond reach from the ground level (Fig. 3.17).

Flower scissor

A flower scissor is used for cutting the flowers with stems. It has two short blades with handles (Fig. 3.18).

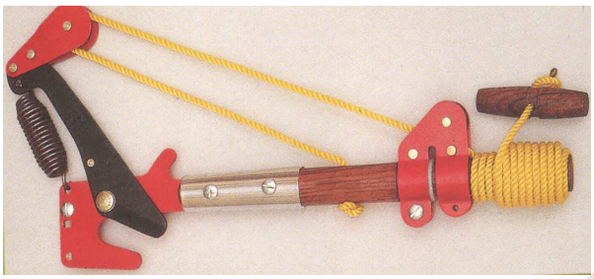

Fig. 3.17: Tree pruner

Fig. 3.18: Flower scissor

Precautions to be taken during the use of tools and equipment

(i) Keep all the tools and equipment out of the reach of children.
(ii) Handle them carefully and follow the instructions given in the manual provided with them.
(iii) If there is any accidental hazard, immediately contact the doctor.
(iv) It is essential to clean the equipment after use.
(v) During the spraying of insecticides, pesticides and fungicides, effective safety measures need to be taken.

Care and maintenance

(i) Ensure cleaning of equipment before and after use.
(ii) Store all machinery and equipment in a dry place.

(iii) Drain the tank and flush it with clean water, wash the pump nozzle before and after the use of sprayer.
(iv) Remove dust from the hopper of the duster and clean it with a cloth.
(v) Overhaul the machines regularly and replace the wornout parts. Grease and oil all moving parts of the machinery as per requirement.
(vi) Do not throw nozzles of sprayers and delivery tubes of dusters on the bare ground.
(vii) Always keep all spare parts in a tool kit.
(viii) Sharpen the blades of harrow, cultivators and cutters regularly.

Practical Exercises

Activity

Identify various garden tools

Materials required: Different types of tools, practical notebook, pencil, pen, etc.

Procedure

Visit a horticultural farm or shop to see different types of tools and equipment being used and note down the following information.

1. Identify different tools and equipment.
2. Write down the names of tools and equipment used.
3. Note down the specific use of each tool and equipment.
4. Draw the diagram of each equipment.

Check your Progress

Fill in the Blanks

1. The tool used for cutting and budding is known as _____.
2. _____ is used for making of cuttings, pruning off pencil thick branches.
3. The tool consisting of two blades with tangs is identified as _____.
4. Grass shears are used for _____ and _____ of the lawn.

Multiple Choice Questions

1. A tool used for making bunds and small plots in a field is called a _____.
   (a) rake (b) shovel
   (c) *khurpi* (d) spade
2. The tool used for collecting weeds and stones is called _____.
   (a) spade (b) rake
   (c) *khurpi* (d) shovel
3. Moving heavy things from one place to another is the function of a _____.
   (a) *khurpi* (b) hand hoe
   (c) wheelbarrow (d) shovel
4. Pruning shoots off trees, which are beyond reach from the ground level is done by a _____.
   (a) pruning saw (b) tree pruner
   (c) secateur (d) flower scissor

Subjective Questions

1. What precautions should be taken during and after the use of a tool or an equipment?
2. Write down the application and structure of the following:
   (a) crow bar
   (b) budding-cum-grafting knife
   (c) hedge shear
   (d) secateur

Match the Columns

A	B
1. Bill hook	(a) Cutting flowers with stems
2. Pruning knife	(b) Application of fungicides
3. Hedge shear	(c) Altering and loosening the soil
4. Secateur	(d) Side dressing of the lawn
5. Grass shear	(e) Making of cuttings
6. Hand cultivator	(f) Trimming, pruning and cutting
7. Sprayer	(g) Remove unwanted twigs or branches
8. Scissor	(h) Heavy pruning operations

Unit 4

Field Preparation and Cultural Operations

Introduction

Before taking flower crops in an open field situation, there are various tasks to be performed for the sustainability of land and other resources. One of these actions involves initial land preparation and various cultural operations, which should be done prior to sowing or transplanting of the plant material. The main purpose of land preparation is to provide necessary soil conditions and enable the plant escape biotic and abiotic stress. This will enhance the successful establishment of the crop and ensure quality produce.

Session 1: Selection of Site for Cultivation of Ornamental Crops

Selection of site

Climate, soil and location are the prime natural components in choosing a site on which the future of flowers depends. It is not a simple task but careful site selection results in the success of flower cultivation. Climate includes several factors, such as temperature, rainfall, atmospheric humidity, altitude, wind and hailstorms, which are mostly encountered. However, high and low temperatures, as well as, hailstorms

are encountered mostly in subtropical plains. Low temperatures and winds are mostly encountered in hilly areas. The location of the site determines its distance from the market, exposure of the Sun, nearness to the road, availability of irrigation water, topography, etc. Distance from the market will determine which particular flowers can be grown and which marketing facilities are available nearby. The land with a gentle slope is more suitable for successful and profitable flower cultivation. Facility of easily available labour and transportation for economic production of crop are also essential.

Necessity for selection of site

Knowledge about the effect of climatic conditions and various types of soil on flower cultivation is important for successfully growing flowers. Different flower crops differ widely in their soil and climatic requirements. Distance from the market will determine which particular flowers can be grown and which marketing facilities are available close by. Soil for open flower cultivation should be fertile and rich in organic matter, nearness to a soft water source and well-drained. Soil pH range should also be neutral or near to neutral. The availability of certain nutrients is strongly influenced by pH as micro-nutrients, such as manganese, iron, copper and zinc become less available in highly alkaline soils. In such soils, the concentration of sodium salts is above 0.1%.

Optimum conditions for the cultivation of flower crops

Ornamental flower crops grow at or above 40° C, such as celosia, amaranth, *kochia*, gaillardia, gomphrena, zinnia, torch lily, cosmos, etc. But most of the commercial crops grow comfortably at a temperature from 15 to 30° C, such as rose, carnation, gerbera, gypsophila, statice, marigold, chrysanthemum, heliconia, bird of paradise, amaryllis and hippeastrum, and so on. Usually, for flower crop cultivation, sandy loam soils with ample humus and a pH range of 5.5–7.5 and roughly EC 1 is preferred. Such soils are easily

workable, have more beneficial soil microbial activity, good soil porosity, and ample water retention capacity, along with a provision for easy access to drainage.

Importance of soil

Soil is one of the most important natural resources of any country. It is the prime structure that provides the necessary environment to support establishment, growth and development of plants. It provides essential nutrients and moisture to the plant for growth and production, holds the root system of growing plants, and allows their stems to grow against gravity. It provides favourable environment of heat, air and water to the growing organism within or over it. Soil serves as a habitat for many micro and macroorganisms.

Soil and its properties

Soil is the upper loose layer of the earth crust rich in nutrients and minerals upon which plants grow and depend for nourishment. The branch of science concerned with formation, nature, ecology and classification of soil is known as 'Soil Science' or 'Pedology'.

Soil may be defined as a natural body developed as a result of pedogenesis (relating to or denoting the process occuring in soil or leading to the formation of soil) processes that take place during and after the weathering of rocks, in which plants and other forms of life can grow.

Pedologist James Samuel Joffe defined soil as— "The soil is a natural body of minerals and organic constituents differentiated into horizons of variable depth, which differs from the materials below, in morphology, physical make up, chemical properties, composition and biological characteristics."

Properties of soil

Soil can be identified or classified according to various characteristics exhibited by it. The properties of soil are helpful in understanding the nature and kind of the soil. Properties of soil can be categorised as physical, chemical and biological.

Physical properties

Soil colour

Soil surfaces, generally, show black, yellow, red and gray hues. The colours of the soil are due to the presence of organic matter minerals and colour of the parent rock. The colour of the surface soil might differ from the colour of its lower layers. Soil colour is an indicator of organic matter content, soil fertility, soil reaction, drainage, aeration and the ecosystem living beneath it.

Soil texture

It refers to the size of soil particles that make the soil. Soil, according to the particle size can be classified as sand, silt, loam and clay. Soil with big size particles is known as 'sand'. The diameter of sand particles is more than 0.2 mm. When the size of soil particles is 0.2–0.02 mm, it is called 'silt'. Loam particles are of 0.02 to 0.002 mm. Clay is the finest particle less than 0.002 mm in diameter. Loamy and clayey soils have good water-holding capacity and are more suitable for the cultivation of flower crops.

Soil density

Soil consists of various particles. It has certain percentage of pore space through which air and water movement takes place. The density of soil is weight per unit volume and it can be shown in two ways — bulk density and particle density.

Particle density: It refers to the actual density of soil solids. It is defined as mass per unit volume of soil solid only. The average value of particle density is about 2.65 g/cm^3.

Bulk density: It is defined as the mass per unit volume, which includes the volume occupied by solids, as well as, pore space. It is, usually, expressed grams per cubic centimetre (g/cm^3).

Porosity

Soil comprises soil particles of different sizes. When soil particles aggregate, some empty spaces are formed between them. These inter-particle spaces of soil are

pores and carry air and water. The quantity and size of pores show porosity of the soil. Soil having more or large pores is called 'porous soil'. Such soils have good drainage and aeration. Soil with small but more pores shows better water-holding capacity. Such soils are water stagnant and are not good for cultivation.

$$\% \text{ Pore space} = 100 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

Soil consistency

The ability of the soil to change the shape or moulding when wet is known as 'soil consistency'. It also ensures pulverising action by implements when dry or the resistance of soil particles to crushing. Soil firmness leads to good tilth and has both micro-pores and macro-pores in more or less equal proportion.

Soil structure

Soil structure refers to the way individual soil particles are arranged to make up the mass of soil (Fig. 4.1).

Practically, soil structure can be described under the following heads:

(1) Platy: Horizontally arranged particles are placed one above the other around a plane
(2) Prism-like or prismatic: Vertically arranged particles or aggregates around a vertical axis
(3) Columnar: These structures are similar to prismatic except slightly rounded vertical faces
(4) Spheroidal or franular: Particles arranged around a point with a curved or an irregular surface

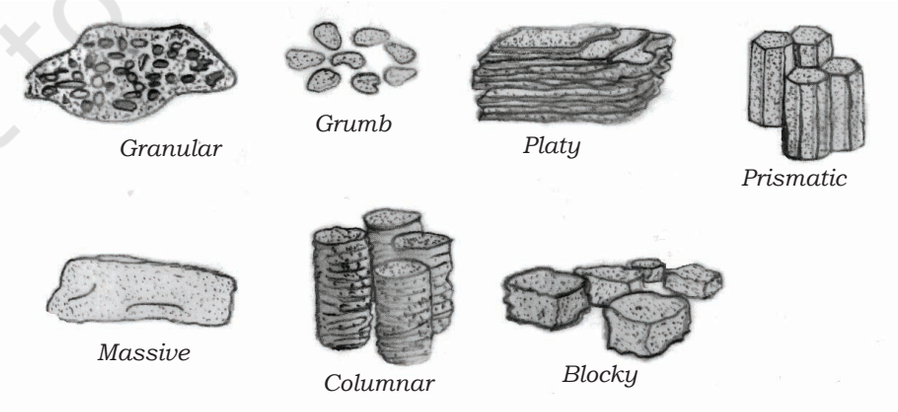

Fig.4.1: Types of soil structure

(5) Block-like or blocky: Particles arranged around a point with a round or flat surface

Soil temperature

It is regulated by the Sun and it helps in the decomposition process within the soil. Low, as well as, high soil temperatures are found harmful for crops. The crops slow down their growth as the temperature falls below 9° C and ceases when it reaches 50° C. Microorganisms of the soil are very active at a range of 27° C to 32° C. There are various factors which include the colour of soil, vegetative cover, soil moisture and slope of the land.

Chemical properties

These properties govern soil fertility. It is related with the ability of the soil to supply nutrients to plants. It depends on the chemical composition of the soil. Chemical properties can be exhibited by soil pH, buffering capacity, soil colloids and cation exchange capacity.

Soil pH

pH of soil shows potentiality of H+ ion. It determines acidic or alkaline reaction of the soil. Hydrogen ion (H+) concentration shows the acidic nature of soil, while concentration of hydroxyl (OH-) ion represents alkaline nature. Slightly acidic soils are more suitable for plant growth. Maximum plant nutrients are available to the crops, when the pH ranges from 6.5 to 7.0. The pH of soil can be measured by soil pH metre, pH scale, etc. pH scale has a range from 0–14pH. A pH of 7 indicates equal concentration of H+ and OH- ions. As the value decreases, it indicates higher concentration of H+ ion. Soils with minimum pH are more acidic. Similarly, as the pH increases above 7, alkaline reaction of the soil increases with the concentration of OH-ion. Such soil is called alkaline soil.

Buffering capacity of soil

The capacity of soil that resists sudden change in the pH of soil is called buffering capacity of soil. Change in pH may affect nutritional balance in the soil, as well

as, microbial activities. Carbonates, bicarbonates and phosphates play buffering agents in the soil.

Soil colloids

These may be clay or humus. Various types of clay found in soil are known as inorganic colloids; while humus is 'organic colloid'. The soil colloids attract positively charged cations because they are negatively charged (anions). Cations hold the water, which is present on the surface of the clay particles until replaced by other cations. Hydrogen ions are the most powerful replacer of cations, which are held by colloids. More the presence of clay particles in the soil, higher is the cation exchange capacity.

Cation exchange capacity

It is the measure of the potential of a soil to hold nutrient cation, such as potassium (K^+), calcium (Ca_2+), magnesium (Mg_2+), sodium (Na+) aluminum (Al_3+), iron (Fe_2+), manganese (Mn_2+), zinc (Zn_2+), hydrogen (H+) and copper (Cu_2+) for plant absorption. Cation Exchange Capacity is a measure of the quantity of cations that can be absorbed and held by a soil. Highly fertile soils, containing high organic matter have more cation exchange capacity. Soil fertility increases with increase in cation exchange capacity.

Biological properties

The soil is inhabited by various types of small living organisms and microorganisms. These are crabs, snails, earthworms, mites, millipedes, centipedes, fungi, bacteria, actinomycetes, protozoa and nematodes. These living organisms feed on plant residues. They make channels and burrow inside the soil, and thus, increase aeration and enhance the percolation of water due to their activities. Their excreta in the form of wastes add to the organic matter of the soil. Bacteria predominate neutral soils, while fungi are more in acidic soils. Moist and shady soils favour the growth of algae.

Soils of India

Soils can be classified as black, red, laterites, alluvial, desert, forest and hilly, peaty and marshy and saline and alkaline soil.

Alluvial soil

This soil is ideal for horticultural production. These soils are found along rivers. They consist of material deposited by rivers during flood situation. These are very productive soils. These greatly differ in colour, texture, drainage conditions, presence or absence of sodium salts, etc. These are suitable for the cultivation of vegetables, flowers and fruits. These soils are found in all States along the rivers. The Indo-Gangetic alluvial soils are the best example.

Black soil

Deep black to light black soils ranges from very fertile to very poor. These are rich in clay (montmorillonite) particles. These have an alkaline reaction. These are rich in bases, lime and calcium as cation. The pH of black soil varies from 7.2 to 8.5. These soils are poor in nitrogen, phosphate and organic matter but rich in potash, calcium and magnesium. These soils are extremely soft when wet, but when dry, they form hard blocks and develop deep cracks. Black soils range from heavy clay (ill-drained) to loams (well-drained), very deep to quite shallow. Black soils are predominant in Maharashtra, Madhya Pradesh, western Andhra Pradesh, southern Tamil Nadu and northern Karnataka.

Desert soil

These soils are sandy in nature and found in low rainfall areas. These are alkaline soils with high pH value and are unproductive. These are rich in soluble salts and poor in nitrogen and organic matter content. Physical conditions of these soils are unfavourable. These soils are found in semi-arid areas of Bihar and parts of Rajasthan.

Forest and hilly soil

These are very shallow soils of higher and lower elevation on the hills. These are stony and infertile for the production of crops. These are low in bases and slightly acidic in reaction.

Lateritic soil (laterite)

These soils form *in-situ* under high rainfall conditions with alternating wet and dry periods. These are red to reddish-yellow in colour. Heavy rains cause the leaching of bases and silica from surface to deep in the soil. These show acidic character with pH of 5 to 6. These are poor in nitrogen, phosphorus, potash, magnesium and lime. These soils are porous and well-drained with poor water-holding capacity. These are found in eastern Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Odisha, Assam and Ratnagiri district of Maharashtra.

Peat and marshy land

These soils are highly acidic in nature and black in colour. Excessive wetness of soil, causing decay and degradation of dead vegetation, forms a layer of partially decomposed organic matter. This gives rise to marshy and peaty soil. These are, generally, found in parts of Bihar, Tamil Nadu and Uttar Pradesh.

Red soil

Such soils result from weathered material of metamorphic rocks. These are porous and friable neutral to acidic in reaction. These soils are poor in humus, nitrogen, lime and phosphate. These are found in parts of Tamil Nadu, Karnataka, NE Andhra Pradesh, eastern parts of Madhya Pradesh, Bihar, West Bengal and Rajasthan.

Acidic and salt affected soil

Acidic soil

Such soils are a result of the parent material. These develop from the weathering of acidic rock, like granite. Sometimes agro-climatic factor, like high rainfall, is responsible for soil acidity. Bases and lime present in the upper layers of soil leached down deep in the soil due to high rainfall or heavy irrigation and make it unavailable. The availability of aluminum increases. Sometimes the addition of fertilisers, such as ammonium sulphate and ammonium chloride, is also responsible for increasing the soil acidity. Microorganisms in the soil decompose organic matter into organic acids.

Soil acidity has a toxic effect on root tissues and affects the permeability of cations. Soil acidity lowers calcium and potassium content and affects the availability of phosphorus, copper and zinc. The balance between base and acidic constitution of plant is disturbed, which affects enzymatic changes. Elements, like aluminum, manganese and iron become toxic in acidic medium. Beneficial activities of soil microorganisms are affected.

Saline soil

These are mostly found in arid and dry regions, where the rate of evaporation is too high. Soluble salts from the lower layer of soils come up and get accumulated due to evaporation of soil moisture. In the catchments, the salts are accumulated by collection of washing of surrounding slopes. Poor drainage and high water table also increases salinity. Irrigation by saline water also causes accumulation of salts in the upper layer of the soil. In saline soils, the presence of white incrustation of salts on the surface is commonly seen. Salinity of soil is due to excess of calcium and magnesium chlorides, sulphates and carbonates. It contains enough soluble salts to interfere with the growth of most crop plants. High evaporation of moisture from soil and low rainfall are the main causes of soil salinity. The exchangeable sodium in saline soil is less than 15% and the pH is below 8.5. The name of electrical conductivity is 4 m mhos/cm, or more at 25° C.

Saline-alkaline soils

Soils show white incrustation of salts on the surface. Such soils are, generally, infertile and poor in drainage. These result from saline irrigation water, and over irrigation for long time, which raises the water table of the soil. These are rich in sodium content and are imporous. Deposition of sodium, magnesium and calcium may be seen on the soil surface. Uttar Pradesh, Punjab, Rajasthan, Kerala, coastal Odisha and Sunderban region of West Bengal form large patches of such soils. These are soils containing soluble salts in sufficient quantities and exchangeable sodium

are more than 15%. The pH of saline-alkaline soil is 8.5 or more. The value of Electrical Conductivity is more than 4 m mhos/cm at 25° C.

Reclamation of soil

- Acid Soil: by adding lime
- Saline Soil: Leaching/ drainage
- Sodic or alakline soil: by adding pyrite/ gypsum

Alkaline soil

These are poor in aeration and drainage. The pH of the soil lies between 8.5 and 10. The exchangeable sodium is more than 15%. The value of Electrical Conductivity is less than 4 m mhos/cm at 25° C. High sodium content is often toxic for crop growth.

Practical Exercises

Activity 1

Identify different soil structure.

Material required: Different types of soil sample, pen, pencil, notebook, etc.

Procedure

1. Visit your vicinity for collecting soil samples.
2. List the soil samples with coding.
3. Write down their physical properties.
4. Identify the types of soil structure.

Activity 2

Determine the nature of soil by pH paper method.

Material required: Conical flask, beaker of 100 ml capacity, distilled water, filter paper, funnel, pH paper, soil sample, etc.

Procedure

1. In a clean conical flask, prepare a solution of given soil sample in distilled water.
2. Filter this solution through filter paper in a beaker.
3. In the filtrate, dip a strip of pH paper. The paper will show change in colour.
4. Compare the colour change with the chart provided over the leaf of pH paper strip packing.
5. Note down the matching reading.
6. Determine the nature by comparing it on pH scale.

Check your Progress

Fill in the Blanks

1. The colour of the soil depends on _____and _____.
2. Transformation of rocks into agricultural land is called _____.
3. The soil can be classified as per the size of soil particles. This is termed as_____.
4. The inter-particle spaces of soil are known as _____.
5. The capacity of the soil to resist sudden change in pH is called _____ capacity of soil.
6. A soil type ideal for horticultural crop is _____.
7. Soil acidity can be corrected by the application of _____ to the soil.
8. Soil science is also known as _____.

Multiple Choice Questions

1. Maximum plant nutrients are available, when the pH ranges from _____.
   (a) 8 to 8.5 (b) 6.5 to 7.00
   (c) 7 to 7.5 (d) 6 to 6.4
2. _____ predominates population of microbes in acidic soils.
   (a) Fungi (b) Algae
   (c) Bacteria (d) Protozoa
3. The pH of black soil varies from _____.
   (a) 7.2 to 8.5 (b) 4.2 to 6
   (c) 6 to 6.5 (d) 6.2 to 6.8
4. The ability of soil to change the shape or moulding when it is wet is due to _____.
   (a) soil structure (b) soil texture
   (c) buffering (d) soil consistency
5. Desert soils are sandy soils found in _____.
   (a) low rainfall
   (b) high rainfall
   (c) moderate rainfall
   (d) None of the above
6. Measuring the quantity of cations that can be absorbed and held by the soil is known as _____.
   (a) pH
   (b) temperature
   (c) buffering
   (d) cation exchange capacity

Subjective Questions

1. Describe the physical properties of soil.
2. Describe acidic soil.
3. What is saline soil? Give the causes of soil salinity.
4. Write the characteristics of the following soils of India:
   (a) alluvial soil
   (b) laterite soil
   (c) black soil
   (d) red soils

Match the Columns

A	B
1. Horizontally arranged particles	(a) 7 pH
2. High organic matter	(b) 8.5–10 pH
3. Neutral pH	(c) Platy structure
4. Alkaline soil	(d) More CEC

SESSION 2: TILLAGE AND CULTURAL OPERATIONS

Preparation of land is important for the cultivation of ornamental crops to ensure that the field is ready for planting. It covers various practices from ploughing to levelling of fields for cultivation.

Preparation of field (tillage)

Ploughing

For the cultivation of flowers, the field should be first dug out to a certain depth in order to improve aeration and drainage, and provide easy space for growth and development of roots. The digging of field is done through plough and the operation is known as 'ploughing'. Ploughing also uproots weeds and previous crop residues. The depth of ploughing should be kept 20–25 cm as superficial ploughing will not favour plant development, whereas, ploughing too deep will bury nutrients and make it beyond the reach of the root zone. Ploughing of the field two to three times across is recommended for better results.

Harrowing

The purpose of harrowing is to break clods after ploughing and smoothening the soil surface for growing ornamental crops. Different types of harrow are used as per the requirement. In general, manures are applied at the time of field preparation and thoroughly mixed by harrowing.

Levelling

After harrowing, the soil is planked to have a uniform level and slope. Levelling of land ensures better implementation of irrigation and planting of crop. Levelling is done to lower the higher parts of the field and soil from higher altitude is spread over the lower regions. After levelling of the land, the desired layout of specific dimensions used for planting, such as ridges and furrows or flat or raised bed, are prepared.

Special practices in flower cultivation

Weeding

It refers to the removal of all unwanted plants from the field, other than those planted or sown. Periodical removal of weeds is beneficial for the growth and development of crop as this prevents competition of weeds with the main crop for sunlight, water, air and nutrients. It is also necessary as weeds harbour many insect pests and diseases. Primary weeding is done to clear huge amounts of plants other than the main crop. In our country, weeding is, generally, carried out manually. Mechanical weeding may conveniently be carried out in those crops, which have been sown or planted as per specification and in rows. However, chemical weeding can be carried out anywhere in any crop, though it may have side effects on the environment. Therefore, mechanical weeding is always preferred. Mulching at the initial stage also minimises weed population.

Mulching

It is a process of covering the soil around plants with organic wastes, like straw, hay, dry grass or leaves, saw dust and crop residues, etc., or synthetic materials, like plastic sheets. This method of mulching is of recent origin. Mulching is a good cultural method that preserves soil moisture, soil erosion and protects weeds. It also helps in maintaining the soil temperature.

Staking

It is a practice to support plants growing straight and saving them from bending or lodging. Therefore, this operation is done at a time when plants are not too tall. It saves the plants from being blown over by winds, rains and due to the weight of their stems when in bloom or in fruiting. Bamboo stakes are most common, and other than this, branches of shrubs and trees, i.e., *neem*, *subabool*, *phalsa*, eucalyptus, etc., can also be used effectively for this purpose.

Earthing up

Digging and pulling the soil in between the rows and heaping it around the stem of plants is called earthing up. In case of bulbous ornamentals, this encourages the development of additional underground food storage structures, such as bulbs, corms, rhizomes or tubers as in case of tuberose, gladiolus, canna, begonia and dahlia.

Deshooting

It is the removal of all side shoots (offshoots/offsets) emerging from the base of the plant. The main purpose of deshooting is to divert the energy of the plant towards the development of shoots or buds.

Disbudding

It is the removal of floral buds when a large flower on a plant is desired, as in chrysanthemum and dahlia.

In this way, the energy saved by disbudding is diverted towards the development of retained bud so the flowers become large and vigorous. Generally, it is followed in large-flowered varieties. In carnation, disbudding is practised to obtain long stalk with larger blooms.

Pinching

It is removal of the growing tips of the vegetative buds to promote bushy growth for more flowering in case of chrysanthemum. It is the removal of 3–5 cm growing tips when the plants are 8–10 cm tall, i.e., when the plants are about one-month old and the second pinching about three weeks after the first pinching. Pinching is also a common practice in carnation and marigold.

Training

It is the shaping of plants at an early stage, conforming to a particular form, commensurate to the plant's requirement. This gives the plant a desired height, shape and strong framework with desired number of properly distributed branches and eliminates weak crotch development.

Pruning

The planned removal of twigs, branches, shoots, limbs, or roots is termed as pruning. Pruning is done with a view to increase the usefulness of the plant.

Principles of pruning

(i) The main principle of pruning is to reduce the apical dominance so that lateral branches are encouraged for quality blooms with long stems as in roses. The ratio between roots and top and vice versa influences the vegetative growth, flowering and fruiting of a plant to a considerable extent. The principle is to strike a balance between shoot and root growth.

(ii) All dead, diseased or insect-infested wood and weaker branches are removed.
(iii) The stronger the growth, the lighter the pruning, and the lighter the growth, the severe is the pruning.

Objectives of pruning

(i) To give a definite direction and shape to the plant
(ii) To develop a strong framework. At an early stage of growth only wide-angled scaffold branches should be retained by proper training.
(iii) To utilise the available space effectively
(iv) To impart dwarfing in the plant and invigorating its growth
(v) To influence productiveness and quality of the produce
(vi) To impart definite objective, such as development of a dense top growth in a shady tree or to keep neat and impenetrable hedge
(vii) To penetrate necessary light and air to inner portion of the plant
(viii) To remove all dead, diseased and interlacing twigs or branches

Time of pruning

(i) The plant bearing flower on last season's growth is, generally, pruned immediately after flowering.
(ii) Those plants flowering on current season's growth are pruned sufficiently ahead of the flowering season.

Practical Exercises

Activity 1

Demonstrate mulching in ornamental crops.

Material required: Different types of mulching material (organic and inorganic)

Procedure

1. Identify and select the mulching material.
2. Apply mulching material in ornamental crops or plots.
3. Observe weed population after two weeks.

Activity 2

Demonstrate pruning.

Material required: Pruning knife, secateur and desired plant.

Procedure

1. Identify and select a plant for pruning.
2. Note down the name, age and stage of the plant
3. Perform pruning with the help of appropriate tools.
4. Observe the growth of the plant after 15 days of pruning.

Check your Progress

Fill in the Blanks

1. Weeding refers to the removal of all _____ plants from the field.
2. Digging and pulling the soil in between the rows and heaping it around the stem of plants is called _____.
3. The main principle of pruning is to reduce the _____.
4. The removal of all side shoots is known as _____.

Multiple Choice Questions

1. Inorganic mulch is _____.
   (a) straw (b) dry grass
   (c) saw dust (d) plastic sheets
2. Earthing up is a common practice in _____.
   (a) rose (b) marigold
   (c) gladiolus (d) carnation
3. Pinching in plants promotes _____.
   (a) plant height (b) flower size
   (c) bushy growth (d) root growth
4. Giving difinite direction and shape to the plant is known as _____.
   (a) pruning (b) pinching
   (c) disbudding (d) deshooting

Subjective Questions

1. What are the various practices for land preparation?
2. Describe in detail the practices followed in flower cultivation.

Match the Columns

A	B
1. Earthing up	(a) removal of unwanted plant
2. Deshooting	(b) planned removal of twigs, limbs, shoots
3. Mulching	(c) acquire desired shape of plant
4. Staking	(d) removal of the growing tips
5. Disbudding	(e) removal of all side shoots
6. Pinching	(f) removal of floral buds
7. Training	(g) support to plant
8. Pruning	(h) bulbous ornamental
9. Weeding	(i) covering exposed soil

Unit 5

Plant Nutrition and Irrigation

Introduction

Nutrition

The elements necessary for normal metabolic activities in the body of an organism are known as nutrients. The process of nutrient supply and their intake is known as 'nutrition'. It has been observed that at least 16 plant food elements are necessary for the growth of plants. These nutrients are called 'essential elements'. In the absence of any one of these, a plant fails to complete its normal life cycle, though the disorder caused can be corrected by adding that element. These 16 elements are carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Molybdenum (Mb), Boron (B), and Chlorine (Cl). Green plants draw carbon from atmospheric carbon dioxide, hydrogen from water and oxygen from atmosphere and water, whereas, the remaining elements are taken from the soil. According to the amount present in the plant, they are grouped as macro- and micronutrients. The elements present in large amount are called macro-elements and those found in small quantities are termed as micro-elements. Iron, manganese, copper, zinc, boron, molybdenum

and chlorine are micronutrients, as only traces of these elements are required. However they are as important as macronutrients, which are required in abundance.

Role of water in plants

Water near the root zone is more important for plants as it creates a favourable ecosystem around the root zone. Water is a good conductor of minerals and nutrients. It maintains turbidity of cell and helps in various biochemical changes within the cell. Water is required for photosynthesis, in which carbohydrates are manufactured and oxygen is released. It is also needed for transpiration and different metabolic activities. Plants, generally, utilise the water present in the soil around the root zone. The deficiency of water near the root zone of a plant can be corrected by irrigation. Rain is the natural source of soil water, but sometimes, rhizospheric moisture has to be maintained through irrigation. For irrigation, different sources of water can be utilised as per convenience. Irrigation water may be taken from surface water as rivers, canals, lakes, ponds, etc., or may be pulled out of the soil (wells and tube wells). Percolation of rains, to improve the soil water level, can be obtained by the construction of soak pits in the field, bunds across the slope of land and planting crops across the slope (contour planting).

Session 1: Plant Nutrients

Role of nutrients in plants

Plant nutrients can be classified according to their function or importance in plant life development and production. This classification includes structural nutrients; accessory nutrients; regulators and carriers; and catalyst and activators.

Structural nutrients

These are of vital importance and required in large quantities and mostly available naturally. These nutrients include Carbon (C), hydrogen (H) and oxygen (O_2).

Accessory structural elements

These are also called 'macro-elements', which can be supplied through manures and fertilisers. These are essential for the growth and production of plants and formation of proteins. These are nitrogen, phosphorus and sulphur.

Regulators and carriers

These elements are potassuim (K), calcium (Ca) and magnesium (Mg), which regulate plant growth and build resistance against crop pests.

Catalysts and activators

Although these are required in very small quantities, they are equally important. These activate various chemical changes within the cell. These are iron (Fe), boron (B), manganese (Mn), molybdenum (Mo), zinc (Zn), chlorine (Cl) and copper (Cu).

Manures and fertilisers

Manures

Manures are decomposed organic matter derived from plants and animals. Besides providing supplement of plant nutrients, manures are beneficial in many ways. They enhance biological activities in the soil, and also improve structure, colour, aeration and water-holding capacity of the soil. Manures are slow in decomposing, hence, they release plant nutrients gradually, which can be used as organic fertilisers in agriculture.

Classification of organic manures

Manures can be classified in three groups as manures of plant origin, animal origin and composite derived from both plants and animals.

1. Manures of plant origin

Oil cake: The solid platy residue left after the extraction of oil from seeds is known as 'oil cake'. These oil cakes are applied to add nutrients to the soil, as well as, to improve the soil structure. The cake formed during the

extraction of oil from seeds may be:

- edible oil cakes: Groundnut cake, linseed cake, rapeseed cake, sesamum cake, etc.
- non-edible oil cakes: *Karanj* cake, neem cake, castor cake, etc.

Plant residues: Straw, husks, stalks, saw dust and wood ash also add nutrients to the soil.

Green manures: Green manure crop is raised and turned into the soil for decomposition. Green manures improve the physical structure of the soil, as well as, soil fertility. Crops, like *dhaincha* and sunn hemp are used as green manure.

2. Manures of animal origin

This includes animal's settled sludge, (dry) dried blood, night soil and sludge manure, fish manure bonemeal, cattle dung and urine mixed, sheep dung and urine mixed, pig manure, poultry manure, etc.

3. Composite manures

Manures are composed of material from both plant and animal origin.

Farmyard manure (FYM): It is well-decomposed dung of cattle, urine along with litter. Usually, dung and urine of animals along with their litter and waste feed are collected and placed in trench daily and when filled in, it is covered with soil. It decomposes in two–three months when it is considered usable in the field. It contains, on an average, 0.5% N, 0.2% P and 0.5% K. Only about 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium content of the FYM are available for uptake by the first crop.

Compost: The mass developed after the rotting of organic matter is called 'compost'. Nowadays, super compost is also in vogue. It is developed using superphosphate @ 10–15 kg/t of raw material used. Farm waste, like sugarcane trash, paddy straw, plant debris, weeds or other waste materials are, generally, used by farmers to get compost. Such types of compost are called 'farm compost'. In contrast, compost made from street sweepings, night soil, dustbin refuse is known as town

compost. The composition of compost varies according to the base material used for decomposition. Farm compost contains 0.5% N, 0.5% p and 0.5% K. Town compost contains 1.4% N, 1.00% p and 1.4% K

4. Vermicompost

Vermicompost is developed using earthworms. Earthworms consume organic matter and excrete it as cast. This cast is used as vermicompost. It is rich in plant nutrients and beneficial bacteria and vescular arbuscular micorrhiza (VAM) fungi. Depending upon the types of base material used, vermicomopst, on an average contains 3% nitrogen, 1% phosphorus and 1.5% potassium.

Vermiwash is drained out extract of vermicompost. To prepare vermiwash, a vermicomposting unit is arranged with water trickling arrangement. This is used as a vermiwash for crop production. It contains more nutrients than vermicompost and finds favour for use as liquid manure.

Table 5.1: Nutrients supplied by manures (%)

S. No	Manure	N (%)	P_2O_5 (%)	K_2O (%)
1.	**Manures of animal origin**			
	a. Dried blood	0.5 – 1.5	0.4 – 0.8	0.5 – 1.9
	b. Fish manure	1.2 – 2.0	1.0	1.5
	c. Bonemeal	0 – 0.7	0.1 – 0.2	0.8 – 1.6
	d. Settled sludge (dry)	3.9 – 4.0	1.8 – 1.9	1.6 – 1.7
	e. Night soil	3.9 – 4.0	0.9 – 1.0	1.3 – 1.4
	f. Cattle dung and urine mixed	5.2 – 5.3	1.0 – 1.1	1.4 – 1.5
2.	**Manures of plant origin**	3.9 – 4.0	1.8 – 1.9	1.6 – 1.7
	a. Cotton seed cake	3.9 – 4.0	0.9 – 1.0	1.3 – 1.4
	b. *Karanj* cake	5.2 – 5.3	1.0 – 1.1	1.4 – 1.5
	c. Neem cake	5.5 – 5.6	1.4 –1.5	1.2 – 1.3
	d. Linseed cake	10.0–12.0	1.0 – 1.5	0.6 – 0.8
	e. Green manure			
	Wood ashes			
	a. Ash coal	0.73	0.45	0.53
	b. Ash babul	0.1 – 0.2	2.5 – 3.0	3.5 – 4.5
	Plant residue			
	Groundnut husk	1.6 – 1.8	0.3 – 0.5	1.3 – 1.7
3.	**Composite manures**			
	a. Farmyard manure (FYM)	0.5 – 0.7	0.4 – 0.8	0.5 – 1.9
	b. Compost (urban)	1.0 – 2.0	10 – 1.2	1.2 – 1.5
	c. Compost (rural)	0.4 – 0.8	0.3 – 0.6	0.7 – 1.0

Fertilisers

They are plant nutrients manufactured commercially from inorganic chemicals. They are ready-to-use nutrients in concentrated forms and contain much higher amount of nutrients than manure and are, therefore, used in small quantities. These chemicals get washed off through irrigation or rainwater and become unavailable at many instances. Chemical fertilisers being the source of a single nutrient is called a 'sole fertiliser'. Fertilisers that supply more than one nutrient are called 'mix' or 'complex fertilisers'.

Advantages

(i) Easily available anywhere
(ii) Calculated amount of nutrients can be applied
(iii) Required nutrient can be specifically applied
(iv) Fertilisers can be carried easily because of packing
(v) Easy to apply in different ways
(vi) Fertilisers are available in different formulations and concentrations
(vii) Nutrients are available at low cost

Disadvantages

(i) Leaches out or infiltrated with rains or irrigation water
(ii) Harmful if applied more than the the required quantity
(iii) Responsible for air and water pollution
(iv) Sometimes, may have adverse effect on soil properties
(v) Have to be stored carefully

Type of fertilisers

Sole fertilisers

These are the fertilisers that supply only a single nutrient. Sometimes it may be accompanied by a minor element. Sole fertilisers are further grouped according to the nutrients they supply.

Nitrogenous fertilisers: These are prepared and applied as a source of nitrogen to the crop. Commonly available nitrogenous fertilisers are urea, ammonium sulphate, calcium ammonium nitrate, etc.

Phosphorus or phosphatic fertilisers: These fertilisers are the main source of phosphorus only. Some commercially available phosphatic fertilisers are single superphosphate, triple super phosphate, dicalcium phosphate.

Potassic fertilisers: These are applied as a source of potassium. Commonly used potassic fertilisers are muriate of potash and potassium sulphate.

Mixed fertilisers (complex fertilisers)

Fertiliser with a source of more than one macro-nutrient for the plant is known as mixed fertiliser. Commonly used mixed fertilisers are di-ammonium phosphate (18:46:0), nitro-phosphate (20:20:0), ammonium phosphate (28:0:0), ammonium phosphate sulphate (16:20:0), calcium ammonium nitrate (8% Ca and 21–27% N), etc.

Almost all fertiliser companies are making soluble and field applicable mixed fertilisers. Now, NPK complex fertilisers are available in varying nutrient contents (19:19:19, 20:20:20, 20:40:0, etc.).

Fertiliser containing micronutrients

Chemical compounds used as a source of micronutrients are of two types, viz.

1. Chelates chemical compounds in the form of heterocyclic ring having a metal ion attached by coordinate bonds to at least two non-metal ions, such as EDTA, DTPA HEDTA, EDDHA, NTA, common chelated micronutrients being Zn-EDTA and Fe-EDTA.
2. Inorganic salts, such as zinc sulphate ($ZnSO_4$), copper sulphate ($CuSO_4$), ferrous sulphate ($FeSO_4$), manganese sulphate ($MnSO_4$), etc., are commonly used as micronutrient fertilisers. All these are soluble in water and can be used as soil application or foliar spray.

Practical Exercises

Activity

Identify various types of manures and fertilisers.

Material required: Samples of different manures and fertilisers

Procedure

1. Observe the given samples carefully.
2. Identify and write the names of the manures or fertilisers.
3. Write in brief their characteristics.
4. Note down the nutrient content of the manures or fertilisers.

Check Your Progress

Fill in the Blanks

1. The elements necessary for metabolic activities of an organism are referred to as _____.
2. The process of supplying nutrients and their intake is known as _____.
3. Green plants draw carbon from atmospheric_____.
4. Accessory structural elements are also called _____.
5. The mass developed after rotting of the organic matter is termed as _____.

Multiple Choice Questions

1. _____ elements are necessary for the growth of plants.
   (a) 16 (b) 14
   (c) 10 (d) 12
2. The elements required by plants in large amount are called _____.
   (a) micro-elements (b) macro-element
   (c) Both (a) and (b) (d) None of the above
3. Accessory structural elements are _____.
   (a) K, Ca, Mg (b) Cl, Br, I
   (c) N, P, S (d) C, H, O
4. The application of manures in soil increases the _____.
   (a) biological activities of soil
   (b) physiological activities of soil
   (c) moisture retention capacity of soil
   (d) All of the above

5. The solid platy residue left after the extraction of oil is known as _____.
   (a) oil (b) oil cake
   (c) essence (d) None of the above
6. Plant manures are composed of material from _____.
   (a) plant origin (b) animal origin
   (c) Both (a) and (b) (d) None of the above
7. Plant nutrients manufactured commercially through chemical process are _____.
   (a) fertilisers (b) biofertlisers
   (c) manure (d) green manures
8. Fertilisers that supply more than single nutrients are called _____.
   (a) sole fertilisers (b) manures
   (c) biofertiliser (d) mix fertilisers

Subjective Questions

1. How can plant nutrients be classified according to their functions in plants?
2. How are manures different from fertilisers?
3. Write down the advantages and disadvantages of fertiliser application.
4. What are the different types of fertilisers?

Match the Columns

A	B
1. Structural nutrients	(a) Fe, B, Mo
2. Accessory structural	(b) K, Ca, Mg
3. Regulators and carriers	(c) N, P, S
4. Catalysts and activators	(d) C, H, O

SESSION 2: APPLICATION OF MANURES AND FERTILISERS

Methods of manure application

In order to get maximum benefit from fertiliers and manures, they should be applied at proper time in proper quantity and in the right manner. The method of manure application depends on its type.

Types of manure

Bulky manures

FYM or other bulky manures should be broadcasted over the entire area and mixed well with the soil by

harrowing. The application of manures depends on the season to avoid leaching of nutrients. In light rainfall areas, the manures may be applied during monsoon, whereas, in heavy rainfall areas after monsoon.

Concentrated manures

Oil cakes, fish manure and bloodmeal are known as concentrated organic manures. These manures should be applied well in advance because they are not available quickly as they have to be broken down by soil microbes and made available to plants.

Farmyard manure (FYM)

Well-rotten FYM can be applied just before sowing and partially rotten FYM has to be applied 20–30 days before sowing. Usually, 10–20 tonne per hectare FYM is applied. It must be made sure that FYM is applied at least two weeks before sowing to avoid immobilisation of nitrogen. FYM is, generally, carried to the field in a cart and dumped all over the field in small heaps. It is then spread all over the field. However, care should be taken that the heaps are not left in the field for a long time as volatilisation loss of nitrogen might take place. The FYM should be preferably incorporated in the soil by deep ploughing or harrowing immediately. It improves the physical, chemical and biological properties of the soil.

Fertiliser application

Time of application

Generally, organic manures are applied while preparing the land so that they improve the structure and water-holding capacity of the soil. Fertilisers are normally applied just before or soon after planting. The frequency and amount of application depends on the crop, soil and season.

Application of fertilisers in solid form

It includes the following methods:

Broadcasting

Basal application

Depending on the crop, broadcasting of fertiliser is carried out prior to sowing and planting just before the last ploughing is incorporated in the field.

Top dressing

When fertilisers are broadcast in the standing crop, it is known as top dressing. In this method, usually, nitrogenous fertilisers and micronutrients are applied in dense sown flower crop.

Placement

Place the fertiliser in well-prepared soil before sowing, irrespective of the position of seeds. There are two types of fertiliser placement techniques.

Plough furrow and single band placement

Application of fertiliser in narrow bands beneath and by the side of crop row/furrow is called 'band placement' of fertilisers. This is done during the process of ploughing. This method can be adopted

- when soil has low fertility,
- when fertiliser reacts with soil constituents leading to the fixation of nutrients, and
- where volatilisation loss is very high. In single band placement, fertilisers are applied on the side of the planted row.

When the fertiliser is applied in two bands, i.e., on both the sides of the planted rows, it is called 'double band placement'. Placement of fertilisers is commonly used for the application of NPK fertilisers in an orchard.

Deep placement

Placement of the fertiliser is, generally, practised for the application of nitrogenous and phosphatic fertilisers and in paddy fields. It is commonly recommended in dry land agriculture.

Ring placement

The quantity of fertiliser per plant is calculated and applied at some depth around the plant circle,this method is mostly practised in orchard crop.

Application of fertilisers in liquid form

Foliar application

It can be used with fertiliser nutrients readily soluble in water. It is also used when there is a soil fixation problem. In this method, it is difficult to apply sufficient amount of major elements. Nutrient concentration of 1% to 2% can be applied without injury to foliage. Foliar application, therefore, is commonly used only to apply minor elements or to supplement the major elements.

Fertigation

This application of fertilisers is through the irrigation water. Nitrogen is the principle nutrient commonly used for this purpose. Potassium and highly soluble forms of zinc and iron can also be readily applied this way. When an element forms precipitate with another substance commonly found in the irrigation water, it is not advisable to use this method. Phosphorus and anhydrous ammonia may form a precipitate in water with high calcium and magnesium content. So they are not used in fertigation. Normally, this system is used through drip irrigation, and liquid fertilisers containing all three major nutrients are normally used.

Green manuring

Some plants, after decomposing, add plant nutrients to the soil and improve the soil condition. Such plants

are called 'green manure crops'. Manuring of the soil by this method is called 'green manuring'. Some green manuring plants at immature or flowering stage are buried as a whole into the soil, while in some cases, only leaves are added to the soil. Selection of the practice depends upon the soil, climatic conditions and availability of green manuring crop.

Plants are grown in the field for 6–8 weeks, and then, they are ploughed and turned in the soil where they have grown. This type of green manuring is called *in situ* practice. These plants are fast-growing, having short life period, and hence, decompose early when added to the soil at a tender stage. Manuring crops are exclusively grown for the purpose and buried before the planting of the main crop or grown as an intercrop along with the perennial crop. This system of manuring is common in northern India. Plants used as a whole for green manuring are *dhaincha*, sunhemp and cluster bean.

In some cases, shrubs or trees of manuring plants are grown on field bunds or in wasteland. This system is common in eastern and central India. Leaves and tender twigs of these plants are collected and turned on while ploughing the main field. The leaves from trees and shrubs used as green manure are *Sesbania speciosa*, *Glyricidia maculata*, *karanj*, etc. These plants are commonly found in the wild, as well as, grown for this purpose.

Advantages of green manure

(i) It improves the soil structure.
(ii) Due to slow decomposition, once applied, it releases gradually.
(iii) It adds organic matter to the soil.
(iv) It lowers the runoff and facilitates the infiltration of rainwater.
(v) Nutrients that otherwise may leach out are held up by plants.
(vi) Leguminous crop when used as green manure fixes nitrogen to the soil through root nodules.

(vii) It stimulates the activity of soil microorganisms.
(viii) It checks the growth of weeds when grown as an intercrop.
(ix) Nutrients at the deeper layer may be brought up by the manure crop.

Bio-fertilisers

They are preparations containing microorganisms, such as bacteria, fungi, and algae in sufficient quantity, helping plant growth and nutrition. Bio-fertilisers help to add, conserve and stimulate plant nutrients in the soil. Some microorganisms fix atmospheric nitrogen symbiotically, some convert insoluble phosphates to soluble phosphates in the soil. They decompose the complex organic matter and make them easily available to plants. Microorganism activities in the soil are significant in improving the soil fertility. Following are the different types of bio-fertilisers.

1. Rhizobium
2. Azotobacter
3. Azospirillium
4. Blue-green algae
5. Azolla
6. Phosphate-solubilising microorganism
7. Mycorrhiza

Bio-fertiliser supplying plant nutrient

Nitrogen

There are three types of nitrogen-fixing bacteria, besides a group of algae. They are:

(a) Symbiotic nitrogen-fixing bacteria, e.g., *Rhizobium*
(b) Associative nitrogen-fixing bacteria, e.g., *Azospirillium*
(c) Free living nitrogen-fixing bacteria, e.g., Azotobacter, Bacillus, etc.
(d) Free-living blue green algae, e.g., *Anabaena, nostoc.*

Phosphorus

There are two types of phosphorus mobilising microorganism:

(a) Phosphate-solubulising microorganism, e.g., Phospho-bacteria
(b) Microorganism helping in phosphorus uptake, e.g., Mycorrhizal fungi.

Use of bio-fertiliser in flower crop

Different types of bio-fertilisers, such as *Azotobacter*, *Azospirillum*, phosphorus solubilising bacteria (PSB) and Mycorrhiza fungi are applied in various flower crops, i.e., tuberose, rose, carnation aster, marigold and jasmine, etc. These bio-fertilisers not only have a limited role in improving the nutrient uptake by plants but also help in enhancing the quality produce of flowers along with reducing the cost of cultivation. These are a potential source of nutrients for sustainable systems of horticulture and floriculture.

In India, commercial use of bio-fertilisers in flower crops is limited. It is used for research and academic purposes only.

Practical Exercises

Activity

Demonstration of application of fertilisers in ornamental crops.

Material required: Fertilisers

Procedure

1. Identify and select the fertilisers for application.
2. Select a crop or a plot for the application of fertiliser.
3. Apply fertiliser, i.e., broadcasting placement.
4. Note the care and precautions to be taken while dealing with chemical fertilisers.

Check your Progress

Fill in the Blanks

1. Nitrogen in ammonia form takes _____ days after application to be available to plant.
2. A fertiliser is readily soluble and easily available to the plant _____.
3. Uniform spreading of manure or fertilisers by hand over the entire surface of field is termed as _____.

4. Spreading or broadcasting of fertilisers in the standing crop is known as _____.
5. When fertiliser is placed in bands to the side of seedling, it is called _____.

Multiple Choice Questions

1. In heavy rainfall areas, the manures may be applied _____.
   (a) after the monsoon
   (b) during monsoon
   (c) before monsoon
   (d) None of the above
2. What about plant nutrient is true?
   (a) Requirements differ with crop and stages of growth
   (b) Efficiency depends on time and methods of application
   (c) Crop response to fertiliser application
   (d) All of the above
3. Nutrients in manures are _____.
   (a) readily available
   (b) not available
   (c) slowly available
   (d) partially available
4. Fertilisers are applied mainly _____.
   (a) to supply nutrients to the crops
   (b) to correct deficiency
   (c) for proper growth and development of crop
   (d) All of the above
5. In which form nitrogen is easily available to plants?
   (a) Nitrate
   (b) Nitrite
   (c) Ammonia
   (d) None of the above
6. Manures and fertilisers can be applied _____.
   (a) during the cultivation of land
   (b) after the seed is sown
   (c) in standing crop
   (d) All of the above

Subjective Questions

1. What are bio-fertlisers? How can they be classified?
2. Write down the precautions that need to be taken while applying bio-fertilisers?
3. What is green manure? What are its advantages and disadvantages?
4. Compare the advantages of green manure and bio-fertilisers.

Match the Columns

A	B
1. BGA	(a) Obligate symbiont
2. PSBF	(b) Bacteria fix nitrogen in leguminous crops
3. *Azolla*	(c) Bacteria also increase mineral and water uptake
4. *Azotobacter*	(d) Cyanobacteria
5. *Azospirillum*	(e) Fern plant, suitable for flooded rice
6. *Rhizobium*	(f) Convert insoluble soil phosphate into soluble forms
7. VAM	(g) Non-symbiotic bacterium

SESSION 3: IRRIGATION AND DRAINAGE

The artificial supply of water to support plant growth and production in the absence of adequate supply of water through rainfall is known as irrigation.

Methods of irrigation

There are three methods of irrigation, viz. surface, sub-surface and aerial, overhead or sprinkler irrigation.

Surface irrigation

There are four ways of applying surface irrigation.

1. Flood irrigation
2. Furrow method
3. Basin method
4. Ring method

Flood irrigation method

It is a traditional practice of irrigation. In this method, water is delivered through pipe or open water channel in a field so that the irrigated water can move freely in all directions and cover the surface of the land in a continuous sheet as in case of flood. The entire field is brought under water through the available irrigation source.

Features

(i) It is followed in densely planted crops.
(ii) It is practised in areas with ample and easily available water.
(iii) It is applied in soils not eroding easily.
(iv) It is given to soils, which are permeable.
(v) It is given in land, which is well-levelled having systematic gradual slopes.

Advantages

(i) It is useful for shallow soil.
(ii) Operation costs are very low.

Disadvantages

(i) As compared to other systems, the water requirement is more.
(ii) Due to runoff and deep percolation, the loss of water is very high.
(iii) There is excessive soil erosion on steep land.
(iv) Loss of manure and fertiliser are eroded from the soil.
(v) It is not recommended in highly spacious crops.
(vi) It enables more weed population in the field.

Border irrigation method

The land is levelled and divided into different strips by making soil bunds of 30 cm height in between each strip. Strips of 3–10 m width and 30–90 m length with 0.5% slope are formed. The width is adjusted so as to permit the water to flow evenly and wet the land uniformly. This system is appropriate for broadcast or crop plant sown lines. Apart from sandy soil, this method is the most suitable of the soil textures.

Advantage

(i) It is suitable to irrigate crops on steep slopes, up to 7 per cent slopes.

Disadvantages

(i) Larger flows are required for irrigating border strip.
(ii) For laying out strip, the land is to be graded uniformly. The water requirement is more.

(iii) It is suited only for soils that do not readily disperse
(iv) To avoid waterlogging, proper drainage system is required.

Furrow (ridges) irrigation method

In this method, water is applied to the field in furrows between two ridges. These furrows are lined among rows of the crop according to the slope of the land. Furrows, 3–6 metres in length, are spread in such a way that water reaches to every nook and corner of the cultivated land. Planting is done in the side of the ridges and water is given through the adjoining furrow. Here, the plant stem does not come in direct contact with water. Irrigation furrows may run straight according to the slope of land, so there is great economy in the use of water.

Advantages

(i) High water efficiency
(ii) Entire land surface is not covered with water so weed problem is minimised
(iii) Can be used in any row crop
(iv) Alternate furrow irrigation may be adopted to save water
(v) Relatively easy in stalling
(vi) Not expensive to maintain
(vii) Adapted to most soils

Disadvantages

(i) More skilled persons are required.
(ii) It is essential to provide drainage system.
(iii) Excess water penetrates at the opening and at the end.
(iv) It is not applicable on uneven land.

Basin method

This method is widely used in orchards. A basin is a small patch of land bunded around a tree. The soil, gradually, slopes down from the base of the tree to the edge of the basin.

Sub-surface method

In this system, the water is led into underground perforated pipes. By the upward capillary movement, the water slowly reaches the root regions of the plant. This method of irrigation is not commonly practised in orchards and plantations.

Sprinkler or overhead irrigation

In this method, water is sprinkled over the crop, as well as, on soil in a circular fashion as rain does. Water with pressure is forced with revolving sprinkler nozzles through pipes fitted with stand. The nozzles revolve due to pressure of water and spread water in the form of thin spray. Water can be applied at controlled rate and distributed uniformly. This is a more efficient system as compared to the other methods. It is an ideal system for hilly and undulating regions, where other systems cannot be used.

Advantages

(i) It ensures uniform distribution of water up to a depth of 10–15 mm.
(ii) It is adaptable to most kinds of soil and useful in plains, as well as, in undulated land.
(iii) This method saves water up to 30–35 per cent
(iv) An increase in yield up to 20–25 per cent has been reported.
(v) Fertilisers and pesticides can also be applied by this method.
(vi) There is no obstacle during the use of farm implements.
(vii) Fertilisers may be applied uniformly through sprinklers.
(viii) More area of land can be covered for irrigation.
(ix) Costly land levelling operations are not necessary.
(x) Amount of water can be controlled to meet the needs of young seedlings or mature crops.
(xi) This system is useful for controlling frost during freezing temperature.

Disadvantages

(i) The installation cost is very high.
(ii) High wind velocity influences the distribution pattern of water
(iii) Regular maintenance of system is required to avoid clogging of nozzles.
(iv) Skilled labourers are required for operation and maintenance of the system.
(v) Water should be free from salts and other suspended matter.
(vi) It requires regular supply of water
(vii) It is not useful in case of tall growing crops with more spacing.

Drip or trickle irrigation

In this system, water is led through plastic pipes, and finally, let out through mechanical devices called 'emitters'. There is a direct and continuous wetting of the root region. This system ensures highest efficiency in the use of water.

Advantages

(i) There is minimum loss of irrigation water by percolation and evaporation.
(ii) Water is supplied as per the requirement of the crop and optimum moisture is always maintained.
(iii) This system also facilitates the supply of liquid fertilisers directly to the roots of the plant through venturi assembly.
(iv) It saves water up to 40–60 per cent.
(v) An increase in yield by 10–25 per cent has been reported in several crops.
(vi) Problem of weed and cost of labour are minimised.
(vii) Low humidity in the field, coupled with weed-free environment, minimises pest attack.
(viii) It is ideal for slopes or undulated land, especially hills.

Disadvantages

(i) The initial cost for the installation of the unit is very high.
(ii) Skilled human resource is required for frequent maintenance.
(iii) It is not suitable where water or sub-soil contains an appreciable amount of salt.

Drainage

Removing excess water by artificial means from the soil is known as drainage.

Drainage problems

(i) Regular drainage avoids accumulation of water around plants. It facilitates the availability of moisture and aeration to roots.
(ii) It eases tillage and other intercultural operations.
(iii) Proper drainage improves the structure of the soil.
(iv) Bacteria that convert organic matter into plant food, get necessary air and warm temperature in well-drained soil.
(v) It improves root development and absorption of nutrients by plants.
(vi) Favourable conditions facilitate seeds to germinate faster.
(vii) Healthy and fast growth crop plants escapes many diseases and pest attack.
(viii) Draining water leached many soluble toxic salts from surface to deep layers of soil.

Advantages

(i) Drainage avoids accumulation of water around the plant. It facilitates availability of moisture and aeration to the roots.
(ii) It eases tillage and other intercultural operations.
(iii) The structure of the soil improves.
(iv) Bacteria, which convert organic matter into plant food, get necessary air and warm temperature in well-drained soil.
(v) It improves root development and absorption of nutrients by plants.

(vi) Favourable conditions facilitate the seeds to germinate faster.
(vii) Healthy and fast growth crop plant escapes many diseases and pest attack.
(viii) Draining water leached many soluble toxic salts from surface to deep layers of soil.

Practical Exercises

Activity

Draw a layout of border irrigation method on a piece of land.

Procedure

1. Level the land and divide it into different strips.
2. Make soil bunds of 30 cm height in between each strip.
3. Make strips of 3–10 m width and 30–90 m length with 0.5% slope.
4. The width is adjusted so as to permit the water to flow evenly and wet the land uniformly.
5. For high value crops or in water scarcity areas, the beds may be still smaller.

Check your Progress

Fill in the Blanks

1. The artificial supply of water to support plant growth and production in the absence of adequate supply of water through rainfall is known as _____.
2. Surface irrigation is irrigation through _____ of the surface, bed or border method, ring and basin method and furrow method.
3. Basin method of irrigation is suitable for _____ crop.
4. An irrigation method that involves slow application of water to the root zone is called _____.
5. Water with pressure is forced through revolving nozzles is _____ system of irrigation.

Multiple Choice Questions

1. Flood irrigation is followed in _____.
   (a) highly spaced crops
   (b) densely planted crops
   (c) Both (a) and (b)
   (d) None of the above

2. Waterlogging (bad drainage) is a problem that arises due to _____.
   (a) excessive or continuous use of water
   (b) hard pan to lower strata
   (c) slow-permeable soils
   (d) All of the above
3. What about the sprinkler system of irrigation is true?
   (a) It saves water up to 30–35 per cent.
   (b) It distributes water up to a depth of 10–15 mm.
   (c) Both (a) and (b)
   (d) None of the above
4. Addition of sulphuric acid or sulphur _____ the pH of irrigation water.
   (a) increases (b) reduces
   (c) neutralises (d) None of the above

Subjective Questions

1. Why is irrigation important for plant life?
2. What are the different methods of irrigation? Describe sprinkler irrigation.
3. Give the merits and demerits of border irrigation system.
4. What is drip irrigation? How is it useful?

Match the Columns

A	B
1. Flood irrigation	(a) Slow application of water to the root zone
2. Border irrigation method	(b) Size of the plot to be irrigated is very small
3. Basin irrigation	(c) Suitable to irrigate crops on steep slopes
4. Furrow (ridges) method	(d) Followed in densely planted crops
5. Sprinkler irrigation	(e) High water efficiency
6. Drip or trickle irrigation	(f) Water is forced through revolving nozzles

Unit 6

Insect Pests, Diseases and Weed Management

Introduction

Insect pests, diseases and weeds are interlinked and complement each other. Individually, each one of these is responsible for a considerable loss by itself but if one remains neglected, it gives rise to the infestation of the other. Some insects secrete a sugary substance on which fungi develop. Weeds serve as the alternate host for rust and other fungi, and also harbour insect pests. Therefore, for efficient insect pests and disease management, it is necessary to also manage weeds. Regular removal of weeds is a type of preventive control as it minimises competition of nutrients, prevents hibernating pests, as well as, facilitates proper aeration and application of pesticides. The key behind the success of insect pests, diseases and weed management lies in early and perfect detection of maladies and their management. Eradicating and treating sources of inocula in the field are important preventive measures. Strengthen the crop by maintaining soil fertility, drainage and aeration check infection from soil, and develop resistance in the crop against pest attack. Infections in the crop may be soil-borne, aerial or seed-borne. Similarly, some insect pests suck the cell-sap of the crop, some chew the foliage and floral parts, some bore into the stems, buds and fruits, while there are insects where their larvae mine the leaves and sometimes even the stems. Each of these problems and infestations need specific approach towards prevention and control. For an

effective strategy on pest management, it is essential to gather technical know-how on identification of the pests. This will be useful for appropriate selection of pesticide with its specific dose, method and time of application.

Session 1: Insect Pest Management

Insect pests

A thorough knowledge of morphology, nature of damage, vulnerable stage of pest, damaging stage, pre-disposing factors, susceptible stages of host, natural enemies and predators help in preventing and controlling them effectively. All insects belong to the class *Insecta*. Their body is segmented and mostly comprises three main segments, i.e., head, thorax and abdomen. Insects have two pair of wings and three pairs of legs. According to structure of wing (*pteron*), they are classified into different orders, such as Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera and Orthoptera, etc. All these insects belonging to different orders may have different life cycles with different damaging stages and nature of damage. With a view to accomplish a better pest management, all these factors are important, but the most important is how (nature of damage) and when (damaging stage) they attack the host.

Table 6.1: Types of insects

Order	Characteristics	Damaging stage
Diptera black flies, mosquitoes and flies (Fig. 6.1)	• A single pair of wings to fly, the hind wings being reduced to club-like balancing organs, hence, is known as halter and balancer. • The mouth parts of these insects are piercing and sucking type. • Life cycle comprises four distinct life stages — egg, larva (maggot), pupa and adult.	Adult and maggots
Coleoptera Beetles and weevils (Fig.6.2)	• These insects have 'sheathed wings'. Their forewings are hardened into a protective covering over the hind wings, which are membranous, and the soft dorsal abdominal wall. • Egg, larva (grub), pupa and adult are distinct stages of life cycle.	The larva known as 'grub' is the damaging stage.

Hemiptera true bugs, hoppers and aphids, scale insects, etc. (Fig. 6.3)	• Insects belonging to this order have half portion of the forewings hard near the base while the remaining half membranous. • These insects may have uniform wings (*homoptera*) or different wings (*heteroptera*). Their young ones are called 'nymphs', who resemble, more or less, their adults. • These have piercing and sucking type of mouth parts. • Life cycle comprises eggs, nymphs and adults.	Nymphs and adults
Hymenoptera bees, wasps, ants, saw flies, etc. (Fig. 6.4)	• The adults have four transparent membranous wings. • Their mouth parts are adapted for chewing. Mouth parts of some species are developed into a lengthy proboscis to suck liquids, such as nectar. • The females can be identified by the presence of typical sting. • Their life cycle comprises eggs, larvae, pupa and adults.	Larvae and adults
Isoptera termites (Fig. 6.5)	• These insects have a well-distributed class system that consists of queen, king soldiers and workers. Hence, these are also called 'social insects'. Nymph stage is the longest stage. Nymphs moult into workers, and later into soldiers. • Life cycle is completed in distinct phases of egg, nymph and adult stage.	Workers feed on cellulose
Lepidoptera butterflies and moths (Fig. 6.6)	• These insects have two pairs of large scale-covered beautiful wings. • Caterpillar is the damaging stage with chewing type of mouth parts, though its adults have sucking type of mouth parts which are known as 'haustellum'. • Haustellum consists of two tubes held together used for sucking nectar. • Life cycle has four stages, i.e., eggs, larvae (caterpillars), pupae and adults.	Caterpillar
Orthoptera grasshoppers, crickets and locusts (Fig. 6.7)	• Insects of this group have parallel-sided structure of the front wings. • Nymph stage is also called 'hoppers'. Grasshoppers, crickets and locusts belong to this group. Crickets have long antennae, while grasshoppers have short antennae. They have biting and chewing type of mouth parts. • Life cycle includes egg, nymph and adult stages.	Nymphs and adults

Thysanoptera thrips (Fig. 6.8)	• These are minute and slender insects hairy feather flat paper-like body with 'fringed wings'. • These have asymmetrical mouth parts. Flight capable thrips have two pairs of strap-like wings. • Their legs, usually, terminate in bladder-like structure. • Life cycle includes eggs, nymphs, pupae and adults.	Adult, nymphs

Fig. 6.1: Diptera

Fig. 6.2: Coleptera

Fig. 6.3: Hemiptera

Fig. 6.4: Hymenoptera

Fig. 6.5: Isoptera

Fig. 6.6: Lepidoptera

Fig. 6.7: Orthroptera

Fig. 6.8: Thysanoptera

Nature of insect damage

Chewing and cutting tissues of the host

These insects have biting and chewing type of mouth parts and may cut, chew and bite the tissues of the host. Infestation of such insect pests is confirmed through this type of damages found on various parts of the host. Mostly larvae and in some cases, adults are responsible for such damages.

Fig. 6.9: Chewing and cutting

Larvae of the Lepidoptera (caterpillars) and the Coleoptera (grubs) are well-known damaging stages that cause such type of damage. Maggots and immature stage of flies feed on flowers of chrysanthemum and many other plants. Sunflower maggots infest the stem and cause collapse of the plant. Larvae of painted lady butterfly, yellow woolly bear, checker spot butterfly, diamondback moth, etc., cause such damages to ornamental crops severely (Fig. 6.9).

Mining in the leaf

Larvae (maggots) of certain leaf minors by mining get inserted between upper and lower surface of the leaf. Irregular tunnel-like structure over the leaf surface is observed due to the feeding of inside tissues. Such infestation may be observed in ornamentals, such as chrysanthemum, dahlia, dianthus, salvia, verbena, etc. This can be identified by the creamy-yellow lines formed on the leaves due to tunneling (Fig. 6.10).

Fig. 6.10: Leaf minor

Boring in the host

Infestation of these pests can be identified by the presence of holes and bores that they make in several plant parts. Beetles, weevils, grubs, caterpillars and maggots are well known that bore into the host and feed on internal tissues. Caterpillars of armyworm bore into flower buds and feed inside. Flowering crops, such as China aster, chrysanthemum, dahlia, delphinium, iris, phlox and salvia, etc., are attacked by

most of the borers. Burdock borer (moth), iris borer, stalk borer and European corn borer are common borers found in ornamentals.

Yellowing and drying of foliage

A wide range of sucking insect pests is responsible for this type of damage. The pest sucks cell sap of the host plant parts (leaves, shoots, floral buds, sepals, petals) to the extent that these are unable to cope up with plant growth and express yellowing, and premature drying or falling off. In most cases, the growth of plant stunts and the plants become unproductive.

Nymphs and adults of aphids, jassids, whiteflies, thrips and bugs are found associated with such damages to almost all ornamentals. Sucking pests are supposed to be dangerous as most of them act as vectors and transmit viral and mycoplasma-like diseases, and aphids and whiteflies secrete honey dew-like substance on which sooty moulds are developed.

Thrips feed on sap and cause white patches on petals and leaves of most of the indoor and outdoor ornamentals. Tarnished plant bugs feed on many flowers. The insect sucks the cell sap and introduces toxic saliva into the plant. It is a serious pest of calendula, China aster, chrysanthemum, cosmos, dahlia, daisy, gladiolus, poppy, salvia, sunflower, verbena, zinnia, and many other ornamentals. Infestation can result in injury to flower buds and dropping of unopened flowers. Two-spotted spider mites infest many commercial ornamentals.

Galls

Sometimes, mites suck cell sap and produce abnormal growth of pimple-like structure on the leaves. Tiny wasps also sometimes produce galls on leaves, stems and twigs of roses and other plants.

Integrated Pest Management

Integrated Pest Management (IPM) is essential to deal with certain diseases, like wilts, and insect pests, such as green worms and spotted worms, by a number of approaches. The disease and insect pests,

if not handled in time can cause huge losses to the crop. Chemicals used against such pests not only have limitations but might have side effects on the plant. Frequent application of insufficient doses of such pesticide build resistance within the organism. Excessive use has residual effect in the crop, which also become a major cause of pollution. Pesticides also inhibit pollinators and predators in the field, which results in reduction of yield.

IPM includes involvement of measures, such as cultural, physical, mechanical, chemical and biological methods against pests.

Insect pest control

Anything that interferes with the life of insect pests and makes them difficult to survive in the field or on plants either by killing them or through repelling so that their population is reduced is known as insect pest control. Various methods for their control are employed.

Cultural methods

Tillage: Ploughing or flooding during summer season exposes hibernating stages of insect pests inside the soil. Stages, like eggs, larvae, pupae of some insects are found hidden deep inside the soil. These are exposed to their natural enemies and the hot Sun due to tillage operation.

Clean cultivation: Weeds and bunds of the field are important foci for hibernating insect pests. Through cleaning of bunds and regular removing of weeds, pest population is minimised. Crop residues of previous crop must be destroyed.

Crop isolation: Crop of the same group or same families, if grown close by, increases the availability of host and this may increase the pest population. If the crop is isolated at a sufficient distance, the movement of pests from one field to another can be avoided, so their control becomes easier.

Altering sowing or planting time: This is a dodging strategy by which the host or its suitable stage is made unavailable for the pest, required for infestation.

Crop rotation: Long crop rotation minimises the invasion of host-specific insect pests.

Eradication of alternate hosts: Weeds or other plants harbouring insect pests in the absence of the major host, if these are removed, break the chain of host availability and control the pest population.

Planting trap crops: Trap crop of less economic value is planted before planting the main crop to attract insect pests towards it and the crop along with pest is destroyed completely before the insect reaches the reproductive phase.

Exclusion of infested plant or part: Removal and destruction of infested plants and their parts reduce population and foci of pest in the field.

Physical methods

These methods are mostly useful in controlling pests in a closed environment, like storage or greenhouse or pot plant. This includes moderation in temperature, radiation and altering humidity of the structure. Drier conditions are unfavourable for pests. Similarly, low temperature of storage inhibits infestation. UV and γ-rays also prove lethal for pests.

Mechanical methods

Removal of infested parts and insect galleries also minimises their population.

Hand picking and destroying: The insects or their eggs can be handpicked and destroyed.

Trenching the field: This causes certain insects to be confined to a patch with no movement elsewhere as locusts.

Screening: Wire mesh protects crops from birds, moths and rodent attack.

Sticky bands: Ants, white ants and other tiny insects stick on the bands and die there without moving anywhere afterwards. Different colours attract insects differently, so coloured papers are pasted on a card board and sticky material is spread over it. Yellow colour attracts white flies.

Light traps: Phototropic insects such as borers (buds, pods and fruits) are attracted to light during night. Light source with a trap of kerosene or some pesticide solution will trap such insects and provide effective control.

Biological control of insect pest

Friendly insects, bacteria and fungi are used in biological control as bio-agents. *Trichograma*, *Crysopa*, Nabid bug, pentatomid bug, big-eyed bug, ladybird beetle (*Epilachna*), tiger beetle, robber fly, cirafid fly, orius bug, tachnid fly, fruit fly, spider and mantids predate over insect pests, and hence, they are known as friendly insects. *Bacillus thuringiensis (BT)* bacterium controls spotted bollworm, pink bollworm, green bollworm, etc.

Spore formulation of *Verticilliumlacani* at the rate of 2.5–5g/litre of water is used to control larvae and nymphs of sucking pests. Whitish growth of *Beauveria* at the rate of 5-10g/litre of water is found to be effective against beetles and their caterpillars. Similarly, *Metarrhizum* greenish growth of the fungus covers the caterpillars and controls beetles, flies and hoppers. Fungus *Hirsutela* is effective against mites. HaNPv *Virus* (Heliothisnucleo poly hydrosis virus) is found effective against bollworm. Various commercial products of above mentioned formulation are available in the market.

Chemical method

Use of chemicals to kill or repel insect pests comes under this method (Table 6.2).

Dust: Dry formulation with inert carrier. Available concentrations are from 1–10%, e.g., Quinolphos 4D, etc.

Wettable (WP), dispersible powder (DP): Dry formulation but can be applied with water, e.g., Carbaryl 75 wp.

Granules: Dry formulation, but particle size is more than found in powder. Applied in soil, e.g., Phorate 10G, Carbofuran 3G, etc.

Emulsifible concentrates (EC): Liquid formulation with emulsifiable agents, which form emulsion in water. Use for aerosol or foliar spray. Most of the insecticides

are available in this formulation, e.g., Cypermethrin 5EC, Malathion 50EC, etc.

Water soluble concentrates (WSC): Easily soluble in water, e.g., Monocrotophos 36WSC, etc.

Fumigants: They are found in liquid or solid form, e.g., methyl bromide, Aluminum phosphide, but these fumigants act in a gaseous state and are used in stored grain.

Table 6.2: Popular pesticides and their dilutions

Technical name	Active ingredient	Formulation	Dose	Use
Carbaryl	50	Powder	0.1%	Foliar spray, soil
Dicofol	18.5	Liquid	0.25%	Foliar spray
Diclorvos	76	Liquid	0.1%	Foliar
Dimethoate	30	Liquid	0.05%	Foliar
Dinocap	25	Liquid	0.05%	Foliar
Malathion	50	Liquid	0.1%	Foliar
Phorate	10	Granule	0.1%	Soil

Practical Exercises

Activity

Identify the major insect pests in your nearby area.

Material required: Insect net, collection box, notebook, pen, pencil, etc.

Procedure

1. Visit a nearby farmer's field and note down the following information:
   - crop grown in the field
   - stage and age of the crop
2. Collect insect pests from the crops.
3. Identify the insect pests.
4. Write control measures of the collected insect pests.

Check your Progress

Fill in the Blanks

1. Tapping of branch on white sheet of paper may detect _____ and _____ incidence.

2. Eradicating and treating sources of inocula in the field is also an important _____ measure.
3. All insects belong to the class _____.
4. Insect body comprises three main segments, i.e., _____, _____ and _____.
5. Greek word *pteron* means _____.
6. Termite belongs to order _____.
7. Larvae of caterpillar belong to order _____.

Multiple Choice Questions

1. The damaging stage of insects belonging to dipteral family is _____.
   (a) larva (b) adult and maggots
   (c) caterpillar (d) grub
2. Caterpillar has sucking-type of mouth parts, which are known as _____.
   (a) homoptera (b) halter
   (c) balancer (d) haustellum
3. The irregular tunnel-like structure over the leaf surface is observed due to the feeding of _____.
   (a) larva (b) maggots
   (c) caterpillar (d) grub
4. Abnormal growth or gall-like structure on the leaves are the damaging sign of _____.
   (a) larva (b) maggots
   (c) mites (d) grub

Subjective Questions

1. What is insect pest control?
2. How are insect pests controlled traditionally?
3. Describe Integrated Pest Management.
4. Write about the following nature of damages:
   - chewing and cutting tissues of the host
   - boring
   - mining leaves
   - galls or hypertrophied structure

Match the Columns

A	B
1. Grub	(a) Caterpillar
2. Lepidoptera	(b) Beetle
3. Nymph	(c) Wasp
4. Diptera	(d) Isoptera
5. Hymenoptera	(e) Maggot

SESSION 2: DISEASE MANAGEMENT

Disease

Any abnormality in the normal functioning of a plant caused by pathogen, which is harmful to the plant or its parts or reduces its economic value is called 'disease'. It is the interaction between susceptible host and virulent pathogen in a favourable environment.

Symptoms of plant diseases

Spot

The cells are killed in a limited area and the dead tissue, usually, becomes some shade of brown. In many cases, other colour changes, such as yellowing, precede the death of cells. The leaf spot diseases are numerous, the same host sometime being affected by many types.

Blight

The term means a burnt appearance. It expresses the sudden death of the plant or its conspicuous parts, i.e., leaves, blossoms. The dead organ of the plant, generally, turns into brown or black and may soon decay.

Damping-off

It is a common and serious disease in nurseries. Damping-off is a pre-emergence and seedling disease caused by various fungi, such as *Pythium*, *Phytopthora*, *Rhizoctonia* and *Fusarium*. These fungi, attack at the time of seed germination. In this disease, near base of the seedlings girdlings takes place and infected seedling collapse due to rotting in the collar region.

Wilt

In many diseases, the most striking effect is drying or wilting of the entire plant. The leaves and succulent parts lose their turgidity and droop. This effect is, generally, seen on young growing tips. Later on, the whole plant may start to dry up.

Dieback

It is a symptom of invasion by one or various pathogens, where first yellowing, then blackening

and then drying starts to take place in plants from top to bottom, pathogens entering through the wounds inflicted by pruning or otherwise. Its initial symptoms are visible as blackening of stem parts but afterwards the whole plant dies.

Necrosis

It means the death of the infected cell or disintegration of tissues. This includes diseases, like blast, blight, canker, damping-off, dieback, rots, bud rot, bulb rot, etc., blight of conifers, fleck of lily.

Powdery mildew

It is characterised by white and powdery fungal growth first on the upper surface of a leaf, then covering the lower surface, stems, thorns and floral buds during prevalence of dry conditions around the roots together with humid conditions in the atmosphere. Affected leaves may fall prematurely and the buds fail to open. The fungus overwinters as stem infections and in dormant buds spreads by air.

Rust

Black, brown, reddish or bright orange pustules appear on both the sides of leaves and expended into a larger spot. These also infect the stems, more serious being during favourable environmental conditions. Infected leaves fall off prematurely and stems are likely to wither.

Root-knot nematodes

They have been found feeding on roots by making galls in roots, which cause foliage yellowing. In severe cases, the plant even dies.

Flower bud rot

It appears as rot of the floral buds. Older leaves develop few deep brown necrotic spots. In humid weather, its infection becomes serious.

Leaf mosaic

Plants look mottled because of dark and light green area and also yellow patches, e.g., viral diseases.

Leaf curl

Leaves get deformed and twisted. They roll or curl towards midrib and become stunted in growth. Whole plant becomes dwarf and gives a sickly look.

Fig.6.11: Black spot of rosetera

Fig.6.12: Rust of Geranium

Fig.6.13: Root-knot nematode

Fig.6.14: Rose mosaic

Fig.6.15: Powdery mildew

Fig.6.16: Leaf curl

Fig.6.17: Gall

Integrated Disease Management (IDM)

It is the integration of the methods used for avoiding and controlling diseases. IDM is defined as a decision-based process, including all possible control measures for optimising the control of pathogen to keep the pathogenic population under control or below the level of economic loss.

Cultural method

Tillage

Soil-borne fungi, bacteria and nematodes, serving as sources of infection, perpetuate in the soil. When the soil is ploughed, they get exposed to high temperature of the Sun. This reduces their population or activity within the soil.

Field sanitation

Plant pathogen (fungi, bacteria, and virus) survives on previous crop residues and weeds in the field may serve as a major source of inoculums. Clean cultivation means removal of crop residues and keeping the bunds clean so that the pest population is minimised in the field. Plant disease can be controlled by regular destroying of the diseased plant or weeds, which disrupt the disease cycle, and thus, prove as an effective source of control.

Crop rotation

The availability of susceptible hosts in every season or consecutive years increases the survival and persistence of diseases. Crop rotation with different crops or families breaks their persistence. Starvation of pests due to unavailability of susceptible hosts for long time makes it difficult for pests to survive.

Resistant varieties

Resistant varieties of flower crops have provided one of the most successful approaches to control plant pathogens of many crops, especially those which cannot be controlled by any other means. Some cultivators are resistant to a particular disease and are inherently less damaged than other genetically related plants growing in the same area.

Alteration in sowing time

Manipulation of sowing time and selection of early or late varieties also dodge pathogens. Certain diseases, like early blight, late blight, etc., are time-bound and require particular stage of growth of the plant to infect. Unavailability of susceptible stage fails to infect.

Seed treatment

Most of the seed and soil-borne diseases, such as damping-off, wilt, rots, dieback, anthracnose, etc., attack the crop through seeds or soil. Seed treatment reduces the chances of infection.

Crop density

High density of crop favours incidence of many diseases. Infections can move easily from a diseased to a healthy plant in a dense field. It is, therefore, desirable to plant the crop at required spacing.

Mechanical methods

It includes uprooting or pruning off diseased plants or parts so that infected material may not be able to transmit pathogens to healthy ones. Training and staking the crop facilitates plants so that their leaves may not come in contact with the soil, and thus, infection or infestation is controlled. Erecting nets, sticky bands and mechanical traps control insect-vectors that may transmit viruses.

Bio-control of plant diseases

This is the most common method adopted nowadays as a biological control against many soil-borne diseases. Fungi *Trichoderma herzianum* and *T. viride*, and bacterium *Bacillus subtilis* have antagonistic properties against many fungi causing wilt and rot. Extracts of some plants are also well-known for their fungicidal properties. These are being used since a long time as pesticides. The extracts may be applied as soil or seed treatment or as sprays.

Chemical control

Use of fungicides

Chemical or combination of chemicals found lethal to fungi and escapes the host from infection is called 'fungicide'. Fungicides, according to their movement in the plant system, are of two types — systemic, which on application on plants gets dissolved in the cell sap and affectivity translocates to the whole system of plant irrespective of the place of application, such as Benlate, Calixin, Carbendazim (Bavistin), Demosan, Ridomil, Sten 50, Thiobendazol, Tilt, etc.; and contact fungicides, whose action on plants is restricted to the area of application, such as sulphur, mancozeb, Zineb, Rovral, etc. (Table 6.3).

Table 6.3: Fungicides and their chemical nature

Diseases	Chemical (fungicides)
Downy mildew, leaf spotting, anthracnose gummosis, collar rot, stem rot	Copper-based fungicide
Powdery mildew, leaf spotting	Sulphur-based fungicide, Dinocap
Seed-borne disease	Carbandazim, Carboxin, Oxathin
Soil-borne infection	Oxathin, formaldehyde

Fungicide application

Soil drenching: In case of soil-borne infection of fungi (wilt, damping off, root rot) or nematodes (root-knot), fungicide or nematicide should be applied to the soil. Such fungicides are carbendazim, formaldehyde, etc. (Table 6.3).

Seed treatment: To avoid infection from the soil, as well as, from the seed, the easy way is seed treatment. Generally, seeds are treated at the rate of 2.0–2.5 g fungicide/kg of seed. Seed dressing drum or earthen

pitcher can be used for treating the seeds. Fungicides used are *Carbandazim*, *Carboxin*, *Oxathin*, etc.

Pasting to affected parts: In case of scorching Sun or in gummosis, the affected parts, such as stem, are pasted with Bordeaux paste.

Foliar application: Aerial parts affected by foliar diseases can be controlled through foliar sprays of fungicidal formulations. Specialised sprayers are available for treatment. Generally, fungicides are sprayed with compatible insecticides, so it reduces the cost of application. These fungicides are sulphur, copper oxicloride, Maneb, Zineb, Nabam, etc.

Dip method: In this method, seedlings and cuttings are dipped before planting in the fungicidal solution for certain period to avoid infection, e.g., Benlate, Captafol, Carbendazim, Maneb, Sulphur, Zineb, etc.

Practical Exercises

Activity

Identify diseased samples of flowering crop

Material required: Diseased samples of different flower crops, etc.

Procedure

Observe the symptoms of diseased samples and write the following information:

1. Name of the crop
2. Name of the disease
3. Causal organism
4. Control measures

Check your Progress

Fill in the Blanks

1. An interaction between susceptible host and virulent pathogen in favourable environment is known as _____.
2. An integrated approach used for avoiding and controlling the diseases is termed as _____.

3. Chemical or combination of chemicals found lethal to fungi and escapes the host from infection is called _____.
4. Affectivity of fungicide when translocated to the whole system of plant irrespective of the place of application, is called _____.
5. Affectivity of the fungicide when restricted to the area of application is called _____.
6. The mechanism of controlling the growth of microorganism through another microorganism is called _____.

Multiple Choice Questions

1. Disease occurs only when there is _____.
   (a) virulent pathogen
   (b) susceptible host
   (c) favourable climate
   (d) All of the above
2. Fungi which have antagonistic properties against many fungi are _____.
   (a) *trichoderm aherzianum*
   (b) *trichoderma viride*
   (c) Both (a) and (b)
   (d) None of the above
3. Neem seed oil can be used effectively against _____.
   (a) *anthracnose*
   (b) charcoal rot
   (c) Both (a) and (b)
   (d) None of the above

Subjective Questions

1. Describe fungicides and their types.
2. Describe different methods of fungicidal application.
3. Describe different cultural methods of disease control.
4. Describe bio-control of disease and antagonism.

Match the columns

A	B
1. Powdery mildew	(a) Use of resistant varieties
2. Bio-control	(b) Sign of gall in roots
3. Cultural method	(c) bright orange pustules appear on leaves
4. Nematode	(d) *Trichoderma spp.*
5. Rust	(e) White fungal growth on leaves

SESSION 3: WEED MANAGEMENT

What is a weed?

An undesirable plant in the field that is responsible for economic losses to the human is called weed. Weeds appear suddenly in the field without any planting or sowing. Weed propagules remain viable for a long time and survive in the field even under odd conditions. Weeds may be categorised as annual, biennial or perennial, according to their life cycle. They can be reproduced by seeds or through vegetative means. Weeds are harmful as these compete with the main crop for nutrients, water, light and space, and badly affect the growth and production of the main crop. Weeds may also act as alternate hosts for many stages of insect pests and pathogens. They occupy land, spread fast, and hence, require regular eradication.

Common weeds of ornamental flowers

Weeds can be classified based on cotyledon and life span.

Based on cotyledon number

Based on the number of cotyledons, weeds can be classified as monocots and dicots.

Monocot weeds

The stem is hollow and round, internodes are short and hard, and the leaves are slender, long and have parallel veins. Most of the grasses belong to this group., e.g., yellow watercrown grass (*Panicum flavidum*), awnless barnyard grass (*Echinochloa colona*).

Dicot weeds

It has taproot system with broad leaves. Veins on leaves are netted and these produce flowers, e.g., blue rattlepod (*Crotalaria verucosa*), bathua (*Chenopodium album*).

Based on life span

Annual weeds

Kankawa (*Commelina benghalensis*), bathua (*Chenopodium album*), hazardana (*Phyllanthus niruri*), biskhapara (*Boerhavia diffusa*)

Biennial weeds

Wild onion (*Allium spp.*), joy weed (*Alternanthera spp.*)

Perennial weeds

Yellow nut sedge (*Cyperus spp.*), Doob grass (*Cyndon dactylon*), Johnson grass (*Sorghum halepense*), Congress grass (*Parhenium spp.*), etc.

Integrated Weed Management (IWM)

IWM involves the utilisation of both preventive and curative measures in a planned way. A combination of exclusion, physical, cultural, chemical and biological methods of weed control is adopted in sequence to bring down the number of weeds below a significant level.

Fig. 6.18: Chenopodium album (Bathua)

Fig. 6.19: Boerhavia diffusa (Biskhapara)

Fig. 6.20: Cyprus spp. (Motha)

Fig. 6.21: Commelina benghalensis (Kankawa)

Fig. 6.22: Phyllanthus niruri (Hazadaan)

Fig. 6.23: Sorghum halepense (Johnson grass)

Preventive method

To avoid introduction and spread of weeds in new locality is known as preventive method of weed control. Spreading of weeds can be avoided by taking the following measures:

- care in transplanting of seedlings
- removal of weeds along irrigation channels and bunds
- sowing of weed-free clean seeds
- use of clean implements
- use of well-decomposed manures
- use of pre-emergence herbicide

Curative method

Eradication of weeds

Complete destruction of weeds from the field is known as eradication. This may be possible only in a small area. This method is, generally, used in high value areas, such as greenhouses, ornamental plant beds and containers. In large areas, it is not possible because some seeds may have very long viability.

Control of weeds

Weed control refers to minimising the infestation of weeds so that the crop can be cultivated successfully. The various methods of controlling weeds are as follows:

Mechanical and physical methods

Mowing the weed

Mowing consists of superficial trimming of succulent and herbaceous weeds. This inhibits the formation of seeds on weeds. Mowing is practised to keep the growth of weeds under check, specially in lawns. It should be followed by other methods of weed control, otherwise it spreads branching of perennials, and so low-growing weeds become a problem.

Mulching the field

It is a practice of covering the open soil in between the rows and plants of the crop. The soil is covered by organic matter, crop residues, polythene or paper. Cover with mulch inhibits sunlight to the exposed areas between the crops. Due to darkness, the weeds are unable to germinate.

Hoeing

This practice is effective in controlling weeds in row crops. It has been a widely used weeding tool for centuries.

Hand weeding

It is effective against annual and biennial weeds. Hand weeding is done by pulling out weeds from the field with the help of a *khurpi*. This facilitates the loosening of soil and improves its drainage and aeration.

Cultural methods

Various agronomic practices, such as crop rotation, intercropping, soil solarisation, etc., have been found effective in weed management

Crop rotation

In mono culture farming, one type of weed grows with one particular type of crop. Crop rotation helps to break the life cycle of weed and prevent any weed species to dominate.

Intercropping

It suppresses the weeds better than the mono cropping system. It gives advantages to utilise crops themselves as tools for weed management.

Transplanting

Healthy and disease-free 4–6 week old seedlings should be transplanted. They have the ability to compete with weeds.

Soil solarisation

It is the method of increasing soil temperature through absorbtion of sunlight, so that it destroys the seeds and other propagules of weeds. Solarisation is done by covering the soil with black polythene during extreme summer for 4 to 6 weeks. The soil temperature may reach up to 40–55° C depending upon the intensity of sunlight. Many annual weeds can be controlled by this method.

Biological method

- Living organisms, such as fungi, bacteria and insects are used to control the weed population. Such herbicides are broadly known as 'bio-herbicides'. When fungal spores or fungi are used to control weeds this is known as myco-herbicide, i.e., *Phythopthora sp.*, *Colletotrichum sp.* and *Bipolari sp.* are in use as myco-herbicides.
- Cochinial insects (*Dactylopius indicus* and *D.tomentosus*) control the Prickly pear plant (*Opuntia sp.*). The larvae of the moth (*Crocidosema lantana*) control the *Lantana camara* plant, which bores into the flower, stems, eat flowers and fruits. *Cuscuta spp.* is controlled by *Melanagromyza cuscutae*, and *Cyperus rotundus* is controlled by moth borer (*Bactra verutana*).
- This method is uncommon as it needs technical knowledge and the success of control is limited. Very few host specific bio-agents are available at present.

Chemical control

As labour being uneconomical, one resorts to intensified use of chemicals in controlling weeds in ornamentals, which is economical. A wide range

of pre-emergence, post-emergence, selective and non-selective herbicides are commonly used to control weeds.

Herbicides

These are organic chemicals which are used in a crop field or elsewhere to control weeds. Herbicides are of two types.

Selective herbicides

These herbicides are used against specific group of weeds and do not prove harmful for other crops. Pendulum, Surflan, Treflan, etc., 2, 4, 5-T, 2, 4-D, etc. kill broad-leaved weeds but do not harm monocots, while Fusilade (fluazifop) controls monocot weeds and not broad-leaved plants.

Non-selective

These are the herbicides that prove lethal to almost all monocots and dicots that come in its contact, e.g., diquat, glyphosate.

Classification of herbicides

Herbicides are classified based on the time of application

Pre-plant herbicides

This is a group of herbicides that is applied before planting the main crop. These herbicides may be fumigants or non-selective chemicals that are lethal to all plants which come in their contact. These are useful in controlling emerged, as well as, emerging weeds. Most of these are applied in soil. Some may be applied on weeds as spray in case of perennial weeds. Pre-plant herbicides include Dazomet, Diquat, Glyphosate, K-pam, metam sodium, pelargonic acid, etc.

Pre-emergence herbicides

These are applied to the soil immediately after sowing the seeds before crop emergence. These herbicides are of selective type, i.e., safest for the crop. Flumioxazin,

Isoxaben, Napropamide, Oryzalin (Surflan), Oxadiazon, oxyfluorfen, Pendimethalin, Prodiamine and Trifluralin are included in this group.

Post-emergence herbicides

These herbicides are applied when weeds and crops have emerged, usually two to three weeks after emergence. These are selective herbicides and used for a narrow range of weeds.

Broad-leaved weeds can be controlled through herbicides containing phenoxy group, e.g., 2, 4-D. Non-selective herbicides are those containing Glufosinate, Diquat, Glyphosate and Pelargonic acid, and plant oils, such as euginol.

Application of herbicides

Success of weed control depends on the method and time of herbicide application. Application of herbicide is more important than herbicides launched at the targeted foci accurately and in measured quantity only. Method of application is as important as the selection of proper herbicide. Different equipment is used for the application of herbicides according to formulation and area to be covered. On small holdings or in greenhouses, it can be applied through back pack hand pump sprayer. In big fields or farms, tractor unit may be more desirable. Over-the-top type sprayer is appropriate for commercial nurseries. To get the most uniform distribution of pre-emergence liquid herbicidal formulations, flat fan nozzles evenly spaced on a boom can be used. Hollow or cone nozzles on a boom is used in case of spraying post-emergence herbicides on weeds. Granular herbicides can be applied through common types of spreaders. Herbicides can be spread by the side-throw-type or drop-type of spreader.

Practical Exercises

Activity

Identify weeds and classify them.

Material required: Weed samples, notebook, pen, etc.

Procedure

Identify the given samples and write following information:

1. Name of the weeds
2. Type: Monocot/dicot/sedge
3. Annual/biennial/perennial

Check your Progress

Fill in the Blanks

1. Undesirable plant in the field that is responsible for economic losses to the human is called a _____.
2. Weeds are harmful as these compete with the _____ for nutrients, water, light and space.
3. Blue grass and chick weed are commonly seen in _____ soils.
4. Spurge pusley and knot weed show the presence of _____ in soil.
5. Young shoots of _____ can be used against asthma and blood disorders.

Multiple Choice Questions

1. Leguminous weeds are commonly seen on _____.
   (a) soil rich in nitrogen content
   (b) soil poor in nitrogen content
   (c) soil rich in phosphorus
   (d) soil rich in calcium
2. Examples of weed that can be used as myco-herbicide _____.
   (a) *Phytopthora sp.*
   (b) *Colletotrichum sp.*
   (c) Both (a) and (b)
   (d) None of the above

3. Herbicides which are applied after weed emergence are called _____.
   (a) pre-emergence herbicides
   (b) post-emergence herbicides
   (c) pre- planting herbicides
   (d) None of the above

Subjective Questions

1. What are weeds and their various types?
2. Describe pre-emergence and post-emergence herbicides.
3. Describe selective and non-selective herbicides.
4. What are the different methods of weed control?

Match the Columns

A	B
1. Monocot weeds	(a) Perennial weeds
2. Dicot weed	(b) Biennial weeds
3. Sedges	(c) Feeding on the weeds
4. Wild onion	(d) Taproot system with broad leaves
5. Pallister beetles	(e) Stem is hollow and round, internodes are short

Glossary

Acid-bog: *a wetland that accumulates peat, a deposit of dead plant material, often mosses*

Actinomycetes: *a specific group of bacteria. Morphologically they resemble fungi because of their elongated cells that branch into filaments or hyphae*

Alkaline soils: *clay soils with high pH (> 8.5), a poor soil structure and a low infiltration capacity*

Biodiversity: *refers to the variety of life*

Bunds: *an embankment or causeway*

Coco peat: *the extraction of coconut fibre from husks gives us this by-product*

Colloids: *a mixture in which insoluble particles of one substance is dispersed and suspended throughout another substance*

Crock: *a broken piece of an earthenware*

Decidous: *those trees or shrubs which shed leaves annually*

Defoliation: *removal of foliage or leaves*

Deshooting: *removal or cutting of shoots*

Disbudding: *removal of buds used in sense of removing flower bud*

Diseases: *abnormality in the normal functioning of the body of an animal/plant*

Fertigation: *a method of fertiliser application, in which fertiliser is incorporated within the irrigation water by drip system*

Fine tilth: *fine textured soil*

Floriculture: *a branch of horticulture, which deals with the cultivation of flowering and ornamental plants*

Flower abortion: *abscission or shedding of premature flowers*

Fumigant: *a volatile or volatilisable chemical compound used to suffocate or poison the pests within*

Girdling: *the complete removal of a strip of bark*

Growing medium: *anything that a plant can grow in*

House plants: *indoor plants*

Hydrometer: *an instrument that measures the specific gravity (relative density) of liquids*

Implement: *tool, utensil, instrument, device, apparatus, contrivance, gadget, contraption, appliance, machine*

Insect: *members of the largest group of hexapod invertebrates within the arthropod phylum*

Landscape: *visible features of an area of land, its land forms and how they integrate with natural or man-made features*

Leaching: *draining away of water, soluble chemicals or minerals from soil*

Loamy soil: *soil composed mostly of sand, silt and a smaller amount of clay*

Marsh: *nutrient-rich wetlands that support a variety of weeds and grasses*

Mechanised farming: *use of machines or automatic devices in farming*

Moulding: *is the shaping of raw material using a solid frame of a particular shape, called a pattern*

NAA: *Naphthalene Acetic acid is an organic compound with the formula* $C_{10}H_7CH_2CO_2H$

Nutraceuticals: *any product derived from food sources with extra health benefits in addition to the basic nutritional value found in foods*

Orchid: *diverse and widespread group of flowering plants, with colourful and fragrant blooms*

Ornamental: *serving or intended as an ornament; decorative.*

Pests: *a destructive insect or other animal that attacks crops, food, livestock, etc.*

pH: *potential of hydrogen ion, is a scale of soil reaction from 0 to 14*

Pinching: *a method of plant pruning used to encourage multiple branches*

Plug trays: *compact design allows you to fit more plants in the greenhouse*

Porous: *material having minute interstices through which liquid or air may pass*

Protozoa: *a diverse group of unicellular eukaryotic animals or organisms with animal-like behaviour, such as motility and predation*

Pulverize: *reduce to fine particles*

Replenishing: *restore to a former level or condition*

Saline soil: *soil containing sufficient neutral soluble salts that adversely affect the growth of most crop plants*

Scion: *a detached living portion of a desirable plant joined to a stock in grafting*

Silty: *fine sand, clay, or other material carried by running water and deposited as sediment*

Solarisation: *use of solar power for controlling soil-borne pests*

Sterilisation: *process that eliminates, removes, kills, or deactivates all forms of life and other biological agents from a medium*

Tang: *the projection on the blade of a knife or other tools by which the blade is held firmly in the handle*

Texture: *the feel, appearance, or consistency of a surface or substance*

Tilth: *the physical condition of soil as related to its ease of tillage, fitness as seed bed and its promotion of seedling emergence and root penetration*

Tines: *a prong or sharp point*

Weathering of rocks: *breaking down of rocks, soil and minerals*

Weed: *undesirable plant*

Further Readings

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Answer Key

UNIT 1: Introduction to Floriculture

Fill in the Blanks

1. herbaceous
2. woody
3. annuals
4. biennials
5. fourteenth
6. indoor gardening
7. lawn
8. planting
9. fillers

Multiple Choice Questions

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

Match the Columns

1. (g) 2. (f) 3. (e) 4. (a)
5. (b) 6. (c) 7. (d)

UNIT 2: Nursery Management

Session 1: Nursery and its Importance

Fill in the Blanks

1. nursery
2. temporary nursery
3. seasonal
4. commercial
5. planting material

Multiple Choice Questions

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

Match the Columns

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

Session 2: Growing Media and Nursery Bed Preparation

Fill in the blanks

1. sunken beds
2. flat beds
3. 15–20
4. soil-borne and seed-borne
5. light and sandy soil
6. poor aeration and stickiness

Multiple Choice Questions

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

Match the Columns

1. (b) 2. (d) 3. (a) 4. (c)
5. (f) 6. (g) 7. (e)

Session 3: Seed Sowing and Planting Material

Fill in the Blanks

1. line sowing
2. pro-trays
3. water-holding
4. damping-off
5. ornamental plant
6. repotting

Multiple Choice Questions

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

Match the Columns

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

UNIT 3: Tools and Equipment

Session 1: Implements used for Preparation of Land

Fill in the Blanks

1. plough
2. 20 cm and above
3. disc plough
4. 50 cm
5. ploughing, harrowing

Multiple Choice Questions

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

Match the Columns

1. (f) 2. (e) 3 (d) 4. (c)
5. (b) 6. (a)

Session 2: Other Tools and Equipment

Fill in the Blanks

1. budding knife
2. secateurs
3. hedge shear
4. trimming and side dressing

Multiple Choice Questions

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

Match the Columns

1. (h) 2. (g) 3. (f) 4. (e)
5. (d) 6. (c) 7. (b) 8. (a)

UNIT 4: Field Preparation and Cultural Operations

Session 1: Selection of Site of Cultivation of Ornamental Crops

Fill in the Blanks

1. organic matter minerals, colour of parent rock
2. soil genesis/pedogenesis
3. soil texture
4. porosity
5. buffering
6. alluvial soil
7. lime
8. pedology

Multiple Choice Questions

1. (b) 2. (a) 3. (a)
4. (d) 5 (a) 6. (d)

Match the Columns

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

Session 2: Tillage and Cultural Operations

Fill in the Blanks

1. unwanted
2. earthing up
3. apical dominance
4. deshooting

Multiple Choice Questions

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

Match the Columns

1. (h) 2. (e) 3. (i) 4. (g)
5. (f) 6. (d) 7. (c) 8. (b)
9. (a)

UNIT 5: Plant Nutrition and Irrigation

Session 1: Plant Nutrients

Fill in the Blanks

1. nutrients
2. nutrition
3. carbon dioxide
4. macro-elements
5. compost

Multiple Choice Questions

1. (a) 2. (b) 3. (c) 4. (d)
5. (b) 6. (c) 7. (a) 8. (d)

Match the Columns

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

Session 2: Application of Manures and Fertilisers

Fill in the Blanks

1. 10 to 15
2. potash
3. broadcasting
4. top dressing
5. band placement

Multiple Choice Questions

1. (a) 2. (d) 3. (d)
4. (d) 5. (a) 6. (d)

Match the Columns

1. (d) 2. (f) 3. (e) 4. (g)
5. (c) 6. (b) 7. (a)

Session 3: Irrigation and Drainage

Fill In the Blanks

1. irrigation
2. flood irrigation
3. orchid
4. drip irrigation
5. sprinkler

Multiple Choice Questions

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

Match the Columns

1. (d) 2. (c) 3. (b) 4. (e)
5. (f) 6. (a)

UNIT 6: Insect Pests, Diseases and Weed Management

Session 1: Insect Pest Management

Fill in the Blanks

1. mites, thrips
2. preventive
3. *Insecta*
4. head, thorax and abdomen
5. wing
6. Isoptera
7. Lepidoptera

Multiple Choice Questions

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

Match the Columns

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

Session 2: Disease Management

Fill in the Blanks

1. disease
2. IDM
3. Fungicides
4. systemic fungicide
5. contact fungicide
6. antagonism

Multiple Choice Questions

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

Match the Columns

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

Session 3: Weed Management

Fill In the Blanks

1. weed
2. main crop

3. nitrogen-rich soil
4. nematode
5. chick weeds

Multiple Choice Questions

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

Match the Columns

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

List of Credits

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Unit 2

Fig.2.1, 2.7, 2.9, 2.10

Unit 3

Fig. 3.3, 3.4, 3.5, 3.6, 3.7, 3.9, 3.10, 3.11, 3.13, 3.14, 3.16, 3.17

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Unit 2

Fig. 2.3, 2.8

Unit 3

Fig. 3.1, 3.2, 3.8, 3.12, 3.15, 3.18

Unit 4

Fig. 4.1

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Unit 2

Fig 2.2	https://bit.ly/2Jh17Ke
Fig 2.4	https://goo.gl/CzZs9f
Fig 2.5	https://goo.gl/Z9mh6R
Fig 2.6	https://bit.ly/2IQSbMw

Unit 6

Fig 6.1	https://bit.ly/2kvWa2w
Fig 6.2	https://bit.ly/2sjexuW
Fig 6.3	https://bit.ly/2LAFenJ
Fig 6.4	https://bit.ly/2s91sVN
Fig 6.5	https://bit.ly/2xiZqan
Fig 6.6	https://bit.ly/2IO2PDH
Fig 6.7	https://bit.ly/2IU6qw3
Fig 6.8	https://bit.ly/2LC2Ok7
Fig 6.9	https://bit.ly/2ktGhcx
Fig 6.10	https://bit.ly/2J5xqvL
Fig 6.11	https://bit.ly/2L1tpWm
Fig 6.12	https://bit.ly/2L1tQjs
Fig 6.13	https://bit.ly/2sjWqWH
Fig 6.14	https://bit.ly/2kt9Xqj
Fig 6.15	https://bit.ly/2IQoviD
Fig 6.16	https://bit.ly/2xgzhcA
Fig 6.17	https://bit.ly/2GUZb5f
Fig 6.18	https://bit.ly/2kiOv7o
Fig 6.19	https://bit.ly/2x5L7G4
Fig 6.20	https://bit.ly/2s6lhwQ
Fig 6.21	https://bit.ly/2KUCosu
Fig 6.22	https://bit.ly/2x99OBO
Fig 6.23	https://bit.ly/2IO0C76