Draft Study Material

Gardener

(QUALIFICATION PACK: Ref. Id. AGR/Q4306)

SECTOR: AGRICULTURE

Grade 12

विद्यया ऽमृतमश्नुते

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NCERT

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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives. The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material. Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material. This material is copyrighted and should not be printed without the permission of the NCERT-PSSCIVE.

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Nutrition and Irrigation

Module Overview

Plant growth is largely dependent upon mineral nutrient availability in right quantity, right place and right time. Plants take up nutrients either from the soil through their roots or from the environment through their aerial parts especially the leaves or aerial roots and manufacture their food using carbon dioxide and water in the presence of sunlight and green pigment called chlorophyll If plants do not get the essential nutrients for their growth, their growth and development will be poor and deficiency symptoms develop, ultimately leading to death of the plant. Therefore, it is essential that the medium in which plants grow (generally the soil) should contain adequate nutrients for proper growth of the plants. Manures and fertilizers are applied in the soil in case there is deficiency of any nutrient.

Animals and plants sustain their lives with water which constitutes about 35-95% of the plant. Application of controlled amount of water to plants at desired intervals is called Irrigation. Water helps in transportation of nutrients to the plant; regulation of temperature and maintaining turgidity of plant cells.

Learning Outcomes

After completing this module, you will be able to:

- Describe the essential nutrients for plant growth, role of each nutrient, and identify signs of nutrient deficiencies.
- Explain the differences between organic manures and chemical fertilizers.
- Describe the principles and methods of irrigation, the significance of water management, and the tools and strategies for efficient and sustainable irrigation practices.

Module Structure

- Session 1: Plant Nutrition
- Session 2: Application of Manures and Fertilizer
- Session 3: Irrigation

Session 1: Plant Nutrition

Nutrition

There are 17 essential elements required for normal metabolic Activities of the plant which are absorbed in the required quantities to sustain the normal Activities of the plant like photosynthesis, reproduction, growth and development, etc. In the absence of any one of these nutrients, a plant develops deficiency symptoms and fails to complete its life cycle, although the disorder caused can be corrected by addition of that element.

Green plants draw carbon from atmospheric carbon dioxide, hydrogen from water and oxygen from atmosphere and water, whereas remaining nutrients are taken up from the soil. According to their requirement in plants, nutrients are grouped as macro (required in larger quantity) and micronutrients (required in trace amounts). Although all elements are equally important irrespective of the required quantity in the plant. These nutrients are

1. Manures, their classification and uses

Manures

Manures are decomposed organic matter of plant and animal origin which supplement plant nutrients released slowly in the soil. Additionally manures increase soil microbiological Activities and improve structure, aeration and water holding capacity of the soil.

The manures can also be classified as bulky manures (larger quantities are added because the concentration of nutrients is less eg. FYM, compost, green manure) and concentrated manures (applied in lesser quantities in the field as they have more concentration of nutrients e.g. oil cakes, blood meal, fish meal, etc.)

1.1 Manures of plant origin

Oilcake: The solid platy residue left after crushing and pressing oilseeds for extraction of oil is known as oilcake. These add nutrients to the soil as well as improve soil structure. These may be edible oilcakes e.g. Groundnut cake, Linseed cake, Rapeseed cake, etc. or non-edible oilcakes such as Cotton cake, Karanj cake, Neem cake, etc.

Green manures: Crops like Sunhemp, Dhaincha, Guar and Cluster Bean are raised in the field and turned into the soil for its decomposition while they are still tender green and succulent and used as green manures. Green manure crop is raised. Green manures improve physical structure of the soil as well as soil fertility. Tender green plants or plant parts may be collected from wasteland and

spread in the field and incorporated into the soil by ploughing. Some examples for plant species suitable for green manuring are Gliricidia, Sesbania, Karanj, Sunhemp etc.

1.2 Manures of animal origin

This category of manure includes dried blood of animals, settled sludge (dry), night soils and sludge manure, fish manure, bird guano, bone meal, cattle urine mixed dung manure, sheep and goat urine mixed faeces manure, pig manure, poultry manure, etc.

Compost:

Well decomposed plant and animal remnants of organic materials are called compost. Composting involves complete decomposition of plant and animal waste before applying into the field. Animal excreta, grazing residues, litters, leaves and branches are allowed to decay in pits, to make compost.

Vermicompost: Organic manure produced with the help of earthworms, fed on partly decomposed plant and animal waste is known as vermicompost. Earthworms are capable of processing partially decomposed waste by feeding on it and passing it through their gut which enriches the compost with microbes and even plant promoting substances over and above the nutrients which are beneficial for the growth and development of plants. *Eisenia fetida* and *Lumbricus rubellus* are some species of the worms useful for production of the compost.

Advantages of manure

- It improves the soil structure.
- Nutrients are available slowly once applied due to slow decomposition.
- It adds organic matter to the soil.
- It lowers the runoff and facilitates infiltration of rain water.
- Nutrients that otherwise may leach out are held up by plants.
- Leguminous crops when used as green manures, fix atmospheric nitrogen to the soil through root nodules.
- It stimulates the activity of soil micro-organisms.
- It checks growth of weeds when grown as intercrop.

Disadvantages of manure

- Under in situ method of preparation, it occupies the field for at least two months.
- Successful decomposition of green manuring crop depends on rainfall or irrigation.

- If the crop is not properly decomposed, it may not be utilised by the plants and may even become a home for termites. This happens because of delayed ploughing and lack of sufficient moisture in the field for decomposition.
- Cost of green manure may be higher than the cost of commercial fertilizers.
- Favourable conditions for pests may be created.

Classification of manures and fertilizers

Organic Manures

Inorganic (Chemical) Fertilizers

Bulky Organic Manures

1. FYM
2. Compost
3. Sewage
4. Sheep folding
5. Green
6. Vermicompost
7. Biofertilizers

Concentrated Organic Manures

1. Edible oil cakes (Ground cake, Til cake etc.)
2. Non edible oil cakes (Karanj, Castor, etc.)
3. Blood meal
4. Fish meal
5. Bone meal

Nitrogenous Fertilizers
Urea, Amnonium Sulphate

Phosphatic Fertilizers
Super Phosphate, Basic Slag

Potassic Fertilizers
Murate of Potash, Sulphate of Potash

Complex Fertilizers
Diammonium Phosphate, Nitro Phosphate

Mixed Fertilizers
Granulated Fertilizers, Mixtures of different grades

Amendments Micronutrients-
Ferrous Sulphate, Manganese Sulphate, Borax, Copper Sulphate

Fertilizers

Fertilizers are the plant nutrients manufactured commercially from inorganic chemicals through chemical processes. They are ready to use nutrients in concentrated forms are therefore used in small quantities. These chemicals get washed off through irrigation or rain water and become unavailable at many instances besides disturbing the soil structure. Fertilizers which are a source of only single nutrient are called sole or straight fertilizers (Table 1.1), while those supplying more than one nutrient are called compound or complex fertilizers.

Advantages

- Easily available everywhere.
- Calculated amount of nutrients can be applied.
- Required nutrient can be specifically applied.
- Field is not occupied for preparation.
- Fertilizers can be carried out easily due to proper packing.
- Easy to apply in different ways.
- Fertilizers are available in different formulations and concentrations.
- Nutrients are available at low cost.
- Disadvantages
- Leaches out with rain/ irrigation water.
- Harmful if applied in quantities more than required.
- Fast uptake and must be applied frequently.
- Responsible for air and water pollution.
- Have adverse effects on soil properties.
- Must be stored carefully.

Table 1.1: Straight fertilizers and their composition

S.No.	Name of Fertilizer	Nitrogen (%)	Phosphorus (%)	Potash (%)
1.	Diammonium phosphate (DAP)	18.0	46.0	-
2.	Ammonium phosphate sulphate	20.0	20.0	-
3.	Urea ammonium phosphate	28.0	28.0	-

4.	Nitrophosphate with potash	15.0	15.0	15.0
NPK complex fertilizers				
5.	**Grade:** (10-26-26)	10.0	26.0	26.0
6.	**Grade:** (12-32-16)	12.0	32.0	16.0
7.	**Grade:** (14-35-14)	14.0	35.0	14.0
8.	**Grade:** (14-28-14)	14.0	28.0	14.0
9.	**Grade:** (17-17-17)	17.0	17.0	17.0
10.	**Grade:** (19-19-19)	19.0	19.0	19.0
11.	**Grade:** (22-22-11)	22.0	22.0	11.0

Complex or compound fertilizers

Fertilizers which are a source of two or more nutrients are known as complex or compound fertilizers (Table 1.2).

Table 1.2: Complex fertilizers and their composition

S.No.	Name of Fertilizer	Nitrogen (%)	Phosphorus (%)	Potash (%)
1.	Diammonium phosphate (DAP)	18.0	46.0	-
2.	Ammonium phosphate sulphate	20.0	20.0	-
3.	Urea ammonium phosphate	28.0	28.0	-
4.	Nitrophosphate with potash	15.0	15.0	15.0
NPK complex fertilizers				
5.	Grade: (10-26-26)	10.0	26.0	26.0

6.	Grade: (12-32-16)	12.0	32.0	16.0
7.	Grade: (14-35-14)	14.0	35.0	14.0
8.	Grade: (14-28-14)	14.0	28.0	14.0
9.	Grade: (17-17-17)	17.0	17.0	17.0
10.	Grade: (19-19-19)	19.0	19.0	19.0
11.	Grade: (22-22-11)	22.0	22.0	11.0

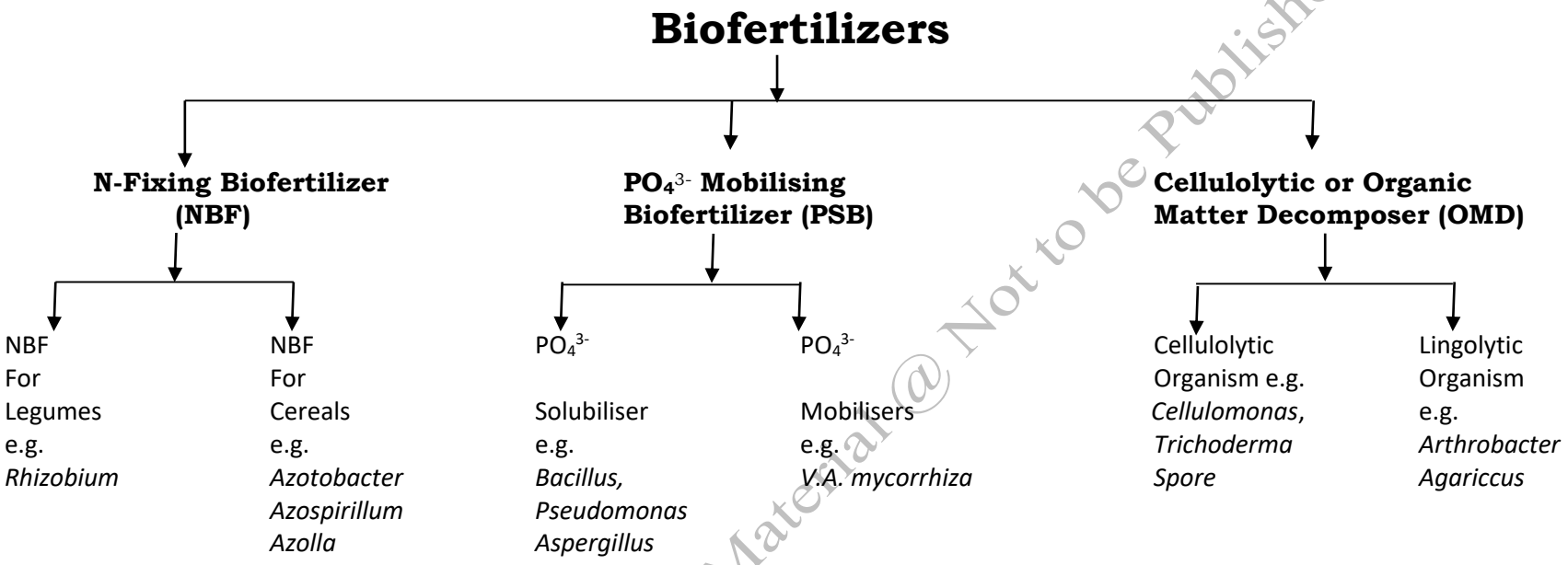
Biofertilizers

Microbial Activities in the soil play a very significant role in improving soil fertility since they decompose the complex organic matter and make it available easily to the plants.

The term biofertilizer includes all such microorganisms which add and conserve nutrients in the soil and bring them in a form suitable for uptake by the plant (VAM: a symbiotic fungal association with plant roots). Some micro-organisms fix atmospheric nitrogen symbiotically (*Rhizobium, Azotobacter* etc.) and some convert insoluble phosphates to soluble phosphates in the soil (Phosphate solubilising bacteria). Thus, their Activities are helpful in increasing soil fertility. Such beneficial microorganisms are used in the form of their cultures called biofertilizers.

Advantages of biofertilizers

- Helps in establishment and growth of plants.
- 10-20 per cent enhancement in biomass production.
- Useful in sustainable agriculture.
- Suitable in organic farming.



Activities

Activity 1: Identify various types of manures and fertilizers.

Materials Required: Samples of different manures and fertilizers

Procedure:

- Observe the given sample carefully
- Identify and write the name of the sample given
- Write its characteristics.
- Write the use of identified fertilizers

Activity 2: Identify various green manuring crops and optimum stage of application.

Materials Required: Various green manuring crops (Moong, Dhaincha, and Sunhemp).

Procedure:

- Visit nearby farmer's field and enlist and observe various types of green manure crops.
- Identify the correct growth stage when the crop is at the threshold tender stage for turning over in the field for decomposition.

Check Your Progress

Fill in the Blanks

1. Intake of necessary elements required for normal metabolic activities of an organism or plant is known as.....
2. For normal growth of green plants, about ..... elements are necessary.
3. Green plants draw carbon from.....
4. The elements required in small quantities are termed as.....
5. Elements ..... are of vital importance and required in large quantities.
6. Decomposed organic matter derived from plant and animal origin are .....

Multiple Choice Questions

1. Urea contains .....per cent nitrogen.

a) 25
b) 40

c) 46
d) 60

2. Fertilizer which contains all the three major nutrients (N, P and K) is.....

(a) Ammonium phosphate sulphate
(b) Diammonium phosphate
(c) Nitro-phosphate with potash
(d) Ammonium chloride

3. Nitrogenous fertilizer is.....

(a) Compost
(b) Super phosphate
(c) Urea
(d) DAP

4. Nitrogen and phosphorus containing fertilizer is.....

(a) CAN
(b) DAP
(c) Urea
(d) Superphosphate

5. Which one is a biofertilizer?

(a) FYM
(b) Azotobacter
(c) Neem cake
(d) Ammonium phosphate

6. Animal origin manure is:

(a) CAN
(b) VAM
(c) FYM
(d) Bone meal

Subjective questions

1. What is manure? Give classification with examples.
2. What are complex or compound fertilizers? Give their composition too.
3. Give the advantages and disadvantages of green manuring.

Match the columns A and B

A	B
1. Nodulation in roots	a. Green manure crop
2. *Azospirillum*	b. Murate of potash
3. Chemical fertilizer	c. Complex fertilzer
4. Daincha	d. Improve root development
5. Dia ammonium phosphate	e. Rhizibium

Session 2: Application of Manures and Fertilizer

To get maximum benefit from manures and fertilizers in agriculture, these should be applied at right place, at right time and in right quantity. The method of manure application depends on type of manure and plant.

Methods of applying manures

i) **Bulky manures:** These manures like FYM should be broadcasted over the entire area and mixed well with the soil using hand hoe. In low rainfall area best application time is before the onset of monsoon, however in heavy rainfall areas, the manures may be applied after the monsoon, so that leaching losses of nutrients can be avoided.

ii) **Concentrated manures:** For the better results these manures should be applied well in advance, before planting. So that concentrated manures can be decomposed by the action of soil microorganisms.

Methods of fertilizer application

Fertilizers application in solid form: It is generally used for lawns and landscaping terrains. It includes the following methods:

I. Broadcasting: It is the most common and simplest method in which fertilizers are spread uniformly manually over the entire surface of field. Broadcasting is further divided in two viz.

(a) Basal dose application (broadcasting at planting) and (b) topdressing (after emergence of crop).

II. **Placement**: The fertilizers are properly placed in the soil before or after sowing of the crops irrespective of the position of seeds, seedlings or growing plants.

Advantages

I. Assures an adequate supply of nutrients to plants from the very beginning.
II. Support a fast early growth of crops

III. Offer time for early intercultural operations for better weed control in the crop fields.
IV. Minimise P and K fixation.

III. Contact placement / combined drilling / drill placement: In this method of application, seed and fertilizers are placed in same row by drilling of seed and fertilizers together at the time of sowing.

IV. Ban placement: Fertilizers are placed in bands on the side of seedlings some distance away from seedlings or at level below or above the seed. These bands may be continuous or discrete in nature. Hill and row placement are most common types of band placement.

V. Pellet application: It is useful in application of nitrogenous fertilizer in the form of pellets 2.5–5.0 cm deep between the rows of the plants. In this practice fertilizer is mixed with soil keeping the ratio of 1:10 and made into dough. Thereafter, small pellets of a convenient size are made and placed in the fields. It increases N fertilizer's efficiency.

VI. Side dressing: This method is very commonly used in tree crops or orchards etc. Inside dressing method, fertilizers are applied in inter row space or around the plants.

Application methods of Biofertilizers

Seed treatment: Seeds to be sown are treated with the biofertilizer inoculant prepared as a slurry resulting in a uniform coating of the inoculants over the seeds. Seeds are shade dried for 30 minutes and sown within 24 hours.

Seedling root dip: It is applicable for transplanted plants. The root of the seedlings is dipped in inoculants solution for 5 to 10 minutes and then transplanted.

Field application: In this inoculant are mixed with powdered and dried manure, after proper mixing this mixture broadcasted in main crop field just before transplanting.

Precautions to be taken in biofertilizer application

a. Mixing of bacterial inoculants should be avoided with insecticide, fungicide, fertilizers and herbicides.
b. The treatment with inoculants should be done just before sowing/ transplanting.

Activities

Apply various types of manures and fertilizers through broadcasting.

Materials Required: Measuring tape, various manures and fertilizers, cloth/jute bag.

Procedure:

- Measure the area with the help of measuring tape, where manures and fertilizers are to be broadcast.
- Calculate the amount of manures and fertilizers to be applied.
- Take the required quantity of different manures and fertilizers in cloth/jute bag and broadcast it uniformly.

Check Your Progress

A. Fill in the Blanks

1. In heavy rainfall areas, the manures may be applied after……
2. Bulky manures like FYM should be ……over the entire area.
3. Application of fertilizers on standing crop is known as……
4. In band placement, fertilizers are placed in bands which may be ……or ……to the side of seedlings.

B. Multiple Choice Questions

1. The term ……refers to the fertilizer placed beside the rows of a crop.

   a) Top dressing
   b) Side dressing
   c) Pellet application
   d) Row placement

2. Manure can be applied.

   a) During the preparation of land
   b) After the seed sown
   c) In standing crop
   d) All the above

3. Bulky manure includes

   a) Biofertilizers
   b) Chemical fertilizers
   c) FYM
   d) Chelated compound

4. Side dressing is commonly used in

   a) Orchards

b) Vegetables
c) Ornamentals
d) Indore plants

C. Subjective questions

1. What are methods of fertilizer application?
2. What are methods of biofertilizer application?

D. Match the columns A and B

A	B
1.Time of manure applications	a. Earthworm
2. Hill placement	b. Close grown plants
3. Rhizobium	c. Wide spaced plants
4.Row placement	d. Seed inoculants
5. Vermicompost	e. Before planting

Session 3: Irrigation

In India, water use efficiency (WUE) as well as agricultural production is still neglected. The low efficiency is mainly due to loss of irrigation water through run off. Micro-irrigation has therefore been introduced. This includes drip and sprinkler methods which are more efficient.

Irrigation systems and methods of application

Irrigation

Irrigation is the artificial application of water to the soil for optimum plant growth. The most common sources of irrigation water in India include rivers, reservoirs, lakes, and groundwater. The natural resources of water should be used in a sustainable manner and should not be over exploited.

Effective irrigation system: The irrigation system is said to be effective when it fulfils the following criteria:

i) The method should be inexpensive and economically justifiable.
ii) Uniform distribution of water in the root zone of the plants.
iii) Water loss should be minimum through run off or through infiltration below the root zone.
iv) Ratio of the water stored at root zone to that delivered to the field should be narrow.

Role of water in plants

Water near the root zone is important for the plants as it creates favourable ecosystem around root zone for uptake of nutrients required by the plants. It maintains turgidity of cells and helps in various biochemical changes within. It

is required essentially for photosynthesis, transpiration and different metabolic activities.

Methods of irrigation

There are basically three methods of irrigation: surface, sub-surface, and micro irrigation.

A. Surface irrigation is through flooding, ring, basin and furrow method.

1. Flood irrigation: A very old practice of irrigation which consists of opening water channel in a plot or field so that water can flow freely in all the directions and cover the surface of the field or bed.

Features

1. Followed in densely planted crops.
2. Practiced in areas with ample and easily available water.
3. Applied in the soils not eroding easily.
4. Applied in the soils which are permeable in nature.
5. Applied in well levelled lands, having systematic gradual slopes.

Advantages

1. Can be used on shallow soils.
2. Can be practiced on undulating surface.
3. Less costly than other methods
4. Does not interfere with use of farm implements

Disadvantages

1. More irrigation water is required.
2. Excessive loss of water, due to poor penetration to root zone where anaerobic conditions occur.
3. Excessive soil erosion on steep land.
4. Fertilizers and FYM are eroded from the soil.
5. Not recommended in highly spacious crops.
6. Promotes weed populations in the field.

2. Basin irrigation: This method is suitable for plantation and other high value crops grown in very small plot. The basin may be of any shape like square, rectangle, circular etc. Ring and basin are commonly used for irrigating crops. A small bund of 15 to 20 cm high is formed around the stump of the tree or plant in the periphery of 30-60 cm depending upon plant species. This method also requires even and levelled land and is fit for most of soils. It has high efficiency in the use of water, but its initial cost of preparation of the basins around the tree is comparatively high.

Advantages

1. Suitable for varying supply of water
2. Water loss through run off is minimised. does not take place
3. Rapid irrigation is possible
4. No loss of fertilizers and organic manures occurs.
5. Suitable mainly for orchards, trees, shrubs etc.

3. Ridge and furrow method: This method is an improvement over flood method. In this method, water is applied to the field in furrows between two ridges. Furrows, 3-6 metres in length, are spread in such a way that water reaches every nook and corner of the cultivated land. Planting is done in the side of ridges and water is given through the adjoining furrow. Irrigation furrows may run straight according to slope of land so there is great economy in use of water. Water does not come in direct contact of the plant stems. This method is commonly adopted in case of vegetables.

Advantages

1. High water efficiency
2. Entire land surface is not covered with water so weed problem is quite minimized
3. Alternate furrow irrigation may be adopted to save water
4. Not expensive to maintain
5. Adapted to most soils.

Disadvantages

1. Requirement of skilled labour is more
2. Hazardous to machinery operation
3. Drainage must be provided
4. Excess water penetrates at the opening and at the end
5. Not suitable for uneven land.

B. Subsurface method

Subsurface irrigation may be natural or artificial. Natural sub-irrigation is possible, where an impervious layer exists below the root zone. Water is allowed into series of ditches dug up to the impervious layer, which then moves laterally and wets root zone.

In artificial subsurface irrigation, perforated or porous pipes are laid out underground below the root zone, and water is fed into the pipes by suitable means. In either case, the idea is to raise the water by capillary movement. This method has high initial cost of establishment but has low maintenance cost. Seepage under this method may lead to a risk of soil becoming saline or alkaline

and deterioration of adjacent land. An evaporation loss in this method is near zero. Loss of land in laying out irrigation systems and implements is negligible. This method is however rarely noticed in our country but is prevalent in countries such as Israel.

C. Micro-irrigation

This method is based on the principle that irrigation water if percolated deep below the root zone is then not available to the plants, similarly water at the surface of soil loses due to evaporation. Here This is suitable for high spacing crops. This irrigation system is comprised of a head, mainline or subline, lateral lines, drip nozzles etc.

Advantages of micro-irrigation

- **Economical use:** This system provides supply of water at regular intervals preventing water stress and thus ensures optimum performance of the plant resulting in higher yield and better quality produce.
- **Improved quality and early maturity:** Damages due to contact of water to the foliage and produce are eliminated. Similarly, even growth rate results in early ripening and improvement in quality.
- **Saving of water:** All percolation and evaporation losses are minimized, resulting in water saving of 30 – 70 per cent.

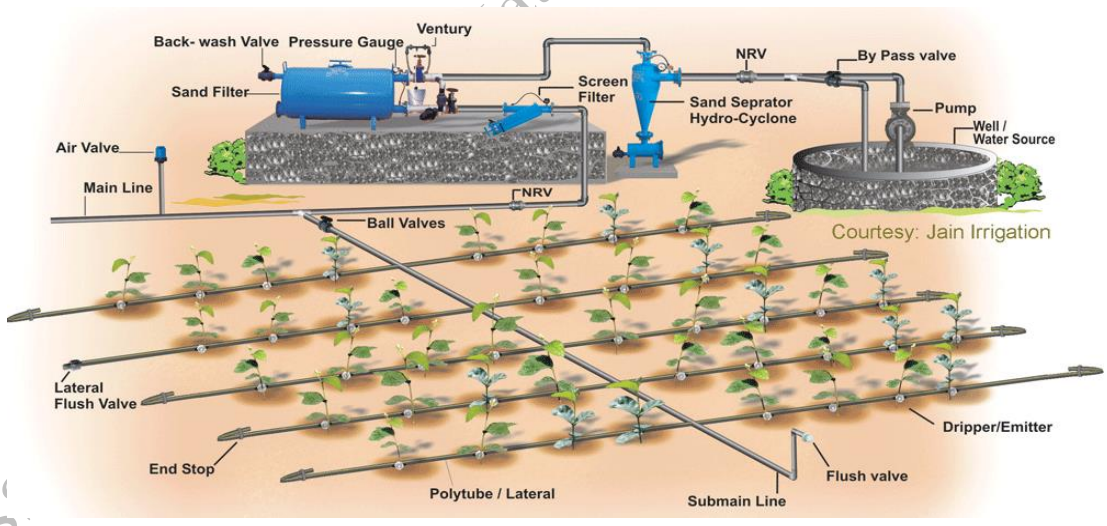


Fig: 1.1: Micro-irrigation system

- **Control of weeds:** Water is applied exactly at root zone of the plant and not to the interspaces between the rows of the plants. This checks the growth of weeds to a great extent.

- **Saving of fertilizers:** Fertilizers can be supplied through the system and applied directly at the root zone of the plant where they are directly utilized. This saves the fertilizers up to 50%.
- **Disease control:** Low humidity, dryness of foliage, weed-free environment and application of various chemicals through the system effectively strengthens the plants against diseases and pest infestation.
- **Increased area under cultivation:** Difficult terrains, sloppy undulating and problematic soils can be brought under cultivation due to possibility of irrigation.
- **Ease in operation:** This irrigation system can be operated during any time of the day and any season of the year.
- **Applicable universally:** It is suitable for majority of fruit crops in the orchard, plantation crops, in landscaping, in lawn, etc.

Disadvantages

- The initial cost of the micro-irrigation for large scale irrigation is its main limitation.
- Requires frequent maintenance.
- It is not desirable where water or sub-soil contains excess amount of salt.

The different kinds of micro-irrigation systems used for gardens are

a. Drip irrigation: water is applied continuously but slowly drop by drop directly to the root zone of the plant with full economy of water. Irrigation water is circulated in whole field through underground pipes having pores near root system of plants.

b. Sprinkler or overhead irrigation

Water droplets are sprinkled over the crops as well as on soil in a circular fashion. Water with pressure is forced with revolving sprinkler nozzles through pipes fitted with stand due to pressure of water and applies water in the form of thin spray. Water can be applied at controlled rate and distributed uniformly. It is particularly useful for sandy soil, uneven topography and shallow soils with high possibility of erosion hazards.

Fig: 1.2: Sprinkler irrigation

C. Fogger: The only difference between the sprinkler and fogger systems is that the size of water droplets applied on plants through the foggers are much smaller than in the sprinkler system.

Advantages

1. Ensures uniform distribution of water up to the depth of 10-15 mm.
2. Adaptable to most kinds of soils and useful in plains as well as in undulating land.
3. Saves water up to 30-35 per cent.
4. Increase in yield up to 20-25 per cent.
5. Fertilizers and pesticides can also be applied along with irrigation.
6. No obstruction in using farm implements
7. Fertilizers can be evenly applied.
8. More land can be covered for irrigation.
9. Expenses on land levelling operations can be saved.
10. Useful for controlling frost during freezing temperature.

Disadvantages

1. Very high initial cost.
2. Wind influences with the water distribution pattern, reducing spread or enhances application rate near lateral pipe.
3. A frequent maintenance is required for its smooth functioning.
4. Labour cost for moving the pipe and related works is additional, cost of operations and maintenance is high.
5. Requires clean water free from physical impurities and salts.
6. Suitable for high value crops.
7. Useful in case of tall growing crops with more spacing.
8. Cause health (disease/insect) problems to sensitive plants.

Drainage

Drainage is the removal of excess water from soil as well as excess gravitational water, which is surplus for the crop, by artificial means, to enhance crop production. Drainage system helps to prevent water logging and to maintain a satisfactory salt balance in the root zone.

Types of drains

- **Surface drains**: Channels are dug out according to slope to carry out the excess irrigation or rain water in the connected channel or river. Disadvantage of this method is that drains divide field into small blocks affecting the tillage and cultural practices and result in wastage of land.

- **Closed drains:** Trenches of 90-120 cm deep at 15-45 m are dug out and filled with alternate layers of sand, boulders, small stone and silt. These trenches have at least 1% slope. Trenches have to be opened in 8-10 years to remove any soil that may choke the drains.

Advantages of drainage

1. Proper drainage avoids the wetting of root to ensure aeration for good plant growth.
2. After receiving the timely rains, the soil comes in tilth earlier and then it becomes possible to carry out timely and proper agricultural operations.
3. The structure of soil improves.
4. Bacteria that convert organic matter into plant food get necessary air and warm temperature in well-drained soil.
5. Good drainage condition promotes chemical reactions, root development and nutrients availability to the crops.
6. Drained crop fields attract less pests and disease
7. Good drainage permits the removal of many toxic salts, and thus reduces damage to crops.

Activities

Visit the nearby drip irrigation system in a field.

Material required: Pen, pencil, notebook.

Procedure:

- Note down the different component of drip irrigation.
- Write the function of different component with the help of farmer
- Draw a diagram showing different parts of drip irrigation system and write down their uses.
- Compare the performance between drip and flood irrigation system

Check Your Progress

A. Fill in the blanks

1. .....is the artificial application of water to the soil for plant growth.
2. Opening water channel in a plot or field in the method of.....
3. Method of irrigation....., which is suitable for orchards and other high value crops.
4. Sprinkler system saves water up to.....
5. ..... is the process of removing excess water from the soil.

B. Multiple choice questions

1. Sprinkler irrigation is most suitable for

   a) Heavy soil
   b) Forest
   c) Indore plants
   d) Uneven topography

2. Irrigation method suitable for orchards is:

   a) Flood
   b) Furrow
   c) Basin
   d) Sprinkler

3. Drip irrigation is a type of:

   a) Micro-irrigation
   b) Overhead
   c) Subsurfaced
   d) Flood

4. Process of removing excess water from soil is known as:

   a) Flooding
   b) Drainage
   c) Sprinkler
   b) None

C. Subjective questions

1. What is irrigation? What are the criteria to decide effectiveness of irrigation?
2. List out different methods of irrigation to crop plants.
3. What is flood irrigation? Describe its features.
4. What are advantages and disadvantages of overhead system of irrigation?
5. What is drainage? Give importance of drainage.

D. Match the Columns A and B

A	B
1. Drip irrigation	a. Very old practice of irrigation
2. Flood irrigation	b. Water saving
3. Sprinkler	c. Liquid fertilizer can be applied
4. Micro-irrigation	d. Water applied as in spray form

Module 2
Care And Maintenance Of Garden

Module Overview

Garden plants need proper care and maintenance throughout their growing periods without, which not only the growth of plants affected but it also gives an ugly appearance to the garden. Plants should be observed keenly on a regular basis, and a schedule of various horticultural operations should be prepared and implanted at regular intervals for good growth and development of plants. Some of the horticultural operations important for care and maintenance of garden plants are nutrition, watering, hoeing, earthing up, thinning, weeding, control of insect- pests and diseases, mulching, staking, pruning, training, etc.

Learning Outcomes

After completing this module, you will be able to:

- Describe the fundamental practices for general care and maintenance of garden plants, including watering, pruning, and soil health management.
- Explain the principles of integrated insect-pest management, including the identification of common pests and the use of biological, cultural, and chemical control methods.
- Describe integrated disease management strategies, including the identification of common plant diseases and the application of preventive and curative measures.
- Understand the principles and methods of weed management, including the identification of common weeds and the use of mechanical, cultural, and chemical control techniques.

Module Structure

- Session 1: General Care and Maintenance of Garden Plants
- Session 2: Integrated Insect-Pests Management
- Session 3: Integrated Disease Management
- Session 4: Weed Management

Session 1: General Care and Maintenance of Garden Plants

The optimum growth and development of the garden plants can be ensured through their care and maintenance on a regular basis. Various horticultural operations which are performed for the healthy growth of plants and appealing garden view are discussed below:

Thinning

Overcrowding of plants in the garden should be avoided whether they are annuals planted in beds or permanent shrubs, bushes, climbers etc. This will regulate plant density and allow proper light and air among the plants, enabling a pleasant appearance of the plants and avoid pests and disease infestation besides preventing hiding of harmful animals in the dense vegetation. The excess annuals, off-type plants and weeds are generally removed with a spud (*khurpi*), which ensures a clean and systematic appearance to the garden.

Weed control

Weed control refers to the removal of all undesirable plants growing in the field other than those planted or sown there. Weeding affects the soil minimally by merely loosening the soil and is beneficial for the growth and development of sown/planted crop as it avoids competition of the main crop for space, sunlight, water, air and nutrients with the weeds. It improves the circulation of air and prevents harbouring of insects and disease organisms. Primarily weeding is done to remove off-type plants other than the main crop. Regular weeding is essential for healthy growth of the main crop and is generally done manually. Mechanical weeding may conveniently be carried out in those crops which have been sown or planted as per specification and in the 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 the preferred method in integrated weed management (IWM).

Chemical herbicides may be non-selective and selective herbicides and are chosen as per the crop requirement. Use of herbicides can also be done on the bare lands to control the weeds. However, care should be taken that garden plants do not come in contact with this herbicide. Hand weeding and hoeing are most common practices to remove weeds on emergence. Mulching at initial stage also minimizes weed population. Therefore, garden should be free from all type of weeds.

Insect-pest control

Various types of insect-pests attack ornamental plants throughout the year which not only mars the aesthetic look of plants but also lead to poor growth and reduction in yield, both quantitative and qualitative. These can be controlled by adopting different integrated pest management methods which include chemical, cultural, biological and manual methods.

Disease control

Diseases of various types infect the ornamental plants round the year which result in diseased, damaged, stunted plants which lack lustre and appeal and ultimately result in death of plants. Infection by diseases not only mars the aesthetic look of plants but also lead to reduction in yield: quantitatively and qualitatively. The various diseases can be controlled adopting integrated disease management methods such as chemical, cultural, biological and manual methods.

Nutrition

The plant growth and quality are largely dependent on mineral nutrients available for the plants. When nutrition is supplied in proper dose, in the proper ratio and at the proper time, the plants can achieve growth many times faster than in nature. There are 17 essential nutrients required for normal developmental Activities of the plant and their uptake and utilisation by plants is known as nutrition. However, deficiency or excess of nutrients in soil can lead to various deficiency or toxicity symptoms, respectively; Therefore, proper scheduling of application of manures and fertilizers for different garden plants should be worked out for healthy growth and development.

Watering: Garden plants should be watered regularly and in required quantities through the various methods of irrigation, both conventional and modern, depending upon the size of the garden and the kind of plants. Excess watering should be avoided, and proper drainage should be ensured since more plants are damaged by overwatering rather than by water stress.

Mulching

Mulch is simply a protective layer of an organic or inorganic/synthetic material that is spread on top of the soil in a 5-10 cm thick layer as a covering material on the ground surface around the growing plants with a view to conserve moisture, obstructing weed emergence and growth, for protecting the plants against cold during winter season by maintaining uniform temperature during growth and for checking erosion. It encourages the activity of earthworms and prevents soil from becoming hard. Organic mulch material such as sawdust, bark chips, seed kernels, rice husks, straw including paddy straw, grass clippings, chopped bagasse, dried leaves, plant debris, *etc.*, decompose in the soil in the long run, forming humus and supplying nutrients to the garden plants. However, inorganic mulches which include stones, brick chips, plastic including the polythene sheets especially the black films, do not provide nutrients to the soil as these do not decompose. Polythene sheets are very

effective for conserving the soil moisture and heat and obstruct weed growth. Mulching has additional benefits such as:

1. Reduces soil compaction from the impact of heavy rains.
2. Keeps fruits and vegetables clean when harvesting.
3. Keeps garden floor clean, allowing access to garden even when damp.
4. Provides a finished look to the garden.

Hoeing

This is another important intercultural operation which is followed in the garden. Hoeing helps to aerate the soil as well as control weed population in the beds. Hoeing is done manually either with *khurpi* or with spade if labour is not a constraint. In larger gardens, a hand hoe or a semi-mechanised hoe can also be used.

Staking

Staking is the practice of providing support to the plants growing straight and preventing them from bending or lodging. Therefore, this operation is done at an early stage when plants are not too tall. Newly planted trees and shrubs also need staking for straight growth of plants. It saves the plants from getting blown over by strong winds, rains and from bending due to the weight of its flowers/fruits when in bloom or in fruiting. Bamboo stakes are most commonly used. However, branches of the shrubs and trees such as *neem*, *subabul*, phalsa, willows, eucalyptus, *etc.* can effectively be used for the purpose. Now a days polyethylene staking nets are also available which can keep the annuals and herbaceous plants erect.

Advantages of staking

1. Optimum utilisation of space.
2. Accommodate more plants per Module area.
3. Keeps vines off the ground.
4. Easier to harvest flowers and facilitates working among the plants.

Earthing up (hilling up)

It is the technique, of piling up soil around the base of a plant. Aeration is improved around the roots and plant is provided with good anchorage so that desired growth is promoted. In case of bulbous ornamentals, it 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 besides preventing lodging of the plants. It is done manually, using a hoe.

De-suckering

De-suckering is removal of all the side shoots (offshoots/offsets/suckers) emerging from the base of the plant before they attain the size of 2.5 cm. The objective is to divert all the energy of plant towards the development of apical bud on the main shoot which has been retained for flowering.

Disbudding

Disbudding is removal of floral buds in the axil of leaves 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 development of the retained apical bud, so the flowers become large and vigorous. Generally, it is followed in large-flowered varieties. The ideal time for disbudding is when the buds surrounding the central one develops 5 cm long pedicels or earlier but not later. Disbudding starts in October or as soon as the flower buds appear. In carnation, disbudding is practiced for obtaining long stalk with larger blooms. The axillary or secondary flowers borne on main stem or terminal shoots are disbudded as soon as they are large enough to handle.

Pinching (stopping)

It is removal of the growing tips of the terminal portion of plants to promote bushy growth for more branching and precocious flowering as 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 done about three weeks after first pinching. To make bushy growth and precocious shooting, further pinching of even the lateral buds can be done if desired. Pinching is also a common practice in carnation and marigold.

Training

Training is 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 a pruning. Pruning is done to maintain the balance between vegetative growth and reproductive growth.

Principles of pruning

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* influence the vegetative growth, flowering and fruiting of a plant to a considerable extent.

Objectives of pruning

1. Utilize available space effectively.
2. Impart dwarfing in the plant and invigorating its lateral growth
3. Influence productiveness and quality of the produce.
4. Impart definite objective such as development of a dense top growth in a shady tree or to keep neat and impenetrable hedge.
5. Penetrate necessary light and air to inner portion of plant.
6. Remove all dead, diseased and interlacing twigs/branches.

Time of pruning

1. The plant bearing flower on last season's growth is generally pruned immediately after flowering.
2. Those flowering on current season's growth are pruned sufficiently ahead of the flowering season.

Method of pruning

The method of pruning varies with the plant specimen as ornamental trees need hardly any pruning so only shrubs are subjected to pruning in the following ways:

(a) Clipping or shearing of hedge: Regular pruning is carried out in hedge plants to maintain its shape *cum* beauty, symmetry and health and to encourage branching from the base so that it becomes impenetrable even to cats and dogs. Square-cut, round-top, wavy-top, columns, animal or bird-shaped, *etc.* are given through training and pruning. During early age, shrubs are headed back frequently to induce branching from ground level till required height is attained. Thereafter, these are sheared more frequently during rainy season.

(b) Topiary: The art of clipping and shearing climbers, shrubs, small trees and herbaceous perennials into various artistic shapes is known as topiary. Plants with small dark-green foliage amenable to frequent clippings and shearing are selected for making topiary. It takes many years to train and shape a plant to desired shape and size. Simple shapes like globe, sphere, dome, table, cube, to difficult objects like birds, animals, beasts or human being may be made with patience. Difficult objects are obtained by training plants with the help of wire

frames. Plants require thorough nourishment. Hanging garden (Kamla Nehru Park, Bombay) is famous for its topiary work. Suitable shrubs are *Clerodendrum inerme* (Glory bower, Indian privet), *Duranta plumieri* (Duranta), *Bougainvillea* (Bougainvillea), *Murraya paniculata* (Kamini), and for simple shapes *Thuja* (Morpankhi), *Cupressus sempervirens* (Italian Cypress), *Putranjiva roxburghii* (Putranjiva), *Vernonia elaeagnifolia* (Curtain Creeper, Vernonia Creeper, Parda Vel), and *Polyalthia longifolia* (Ashoka) are usually used for making topiary.

General principles

1. All dead, diseased or insect infested wood and weaker branches are removed. A sharp cut at an angle of 45 degrees, about 5 mm above a healthy bud facing outside is given.
2. Stronger the growth, lighter the pruning and lighter the growth, more severe is the pruning.

Potting

Ornamental plants can be grown in earthen, plastic, wooden, etc., containers called pots which can be easily shifted from one place to another. Planting of seedlings, nursery plants or any other plant uprooted from soil/growing media can be potted in these pots containing a suitable potting mixture. Potting can be done in the following way (Fig. 2.1):

a. Preparation of pots

- Pots of a proper size according to the plant and having a hole at the base should be selected.
- Crocks or convex, broken pieces of earthen pots of 3-5 cm size should be placed over the drainage hole to avoid clogging of the drainage hole.
- 5-8 cm layer of coarse sand and subsequently potting mixture is filled in the pots leaving a space of 2.5 cm from the rim, for holding water.

b. Potting of plants

- The pot filled thus can be used for sowing seeds, potting of plants or planting cuttings, etc.
- A healthy and well rooted cutting or plant is carefully dug out from nursery bed.
- The plant is placed with ball of earth in the centre of pot.
- Potting mixture is filled around the plant and pressed firmly and uniformly. Care should be taken that ball of earth is not pressed too hard as it will break and damage the roots.
- Watering the plant with a fine nozzle can immediately after planting.
- The potted plant is placed in a cool shady place for its establishment.

- Staking is also provided to support the plant depending upon the nature of plant.
- Deciduous house plants are planted in February-March, while evergreens in July-August.

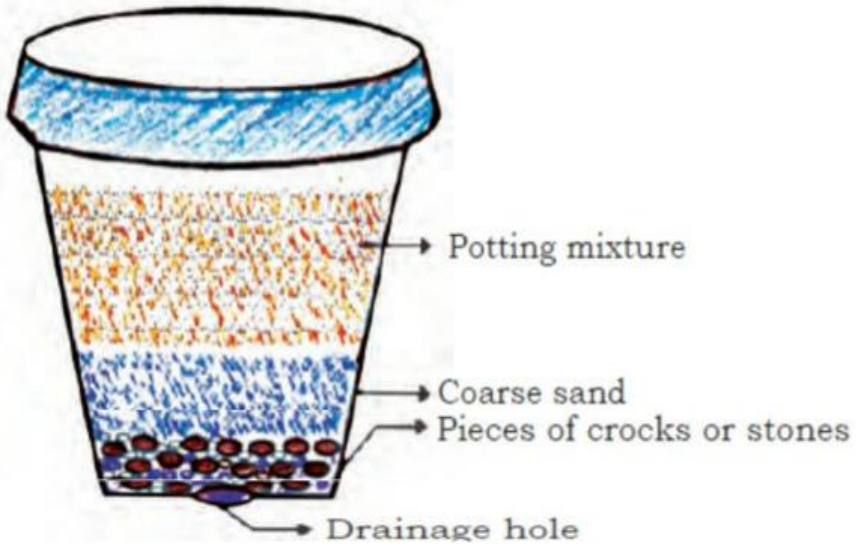


Fig. 2.1: Pot filled with potting mixture

c. De-potting

De-potting is the removal of plants from pots for re-potting or planting in soil or garden bed. As roots are sensitive and prone to injuries, care needs to be taken while de-potting any plant (Fig. 2.2).

- The pot should be watered before de-potting.
- The pot is lifted by right hand, palm spread over the top of the soil holding the stem between second and third finger and the thumb along the side of pot.
- The pot is then turned upside down to remove the plant. If necessary, a gentle tap is given on the rim of the inverted pot against any solid base or on the edge of bench to loosen the earth ball from the sides of the pot.
- The whole earth ball with its intertwining roots of the plant comes out as a single piece and may be 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.
- Plant may be planted in a new pot with newly prepared potting mixture.

Fig.2.2: De-potted plant

d. Repotting

The de-potted plant is repotted in a fresh pot of same or larger size for better growth of house plants. Repotting and transplanting of the established plants is done once in a year or two depending upon the type of plants and their growth habit. Repotting is done when plants become pot-bound or overgrown and the potting mixture becomes devoid of essential nutrients resulting in poor growth of the plants. Depending upon the plant type, repotting is done in February-March or during September-October. During repotting, old potting mixture is replaced by new potting mixture and over-grown roots are removed (Fig. 2.3).

Procedure

- The plant to be repotted is pruned lightly to remove excessive shoot growth. The old potting mixture which is bound by roots is gently removed and the excess roots pruned to reduce the size of earth ball around the plant. Decayed, dead, dried, twisted and unwanted roots are removed with sharp knife or secateurs.
- Plants are placed in the new pot at the same depth in soil at which it was in the old pot. Pot is filled up with fresh potting mixture and then watered immediately.

Fig. 2.3: Plant prepare for repotting

Activities

Weeding, earthing up and staking in gladiolus field.

Materials Required: Gladiolus crop, *khurpi*, spade, bamboo stakes and *sutli*.

Procedure:

- Remove all narrow leaved and broad-leaved weeds of gladiolus crop manually with the help of a spud (*khurpi*).
- Earth up the plants with surrounding soil (10-15 cm above ground level) from all sides of the plants with the help of a spade.
- Fix the straight bamboo stake about 5 cm away from the plant so that the developing corm and cormlets are not injured.
- Hold the plants with spike and straight with the help of stake and tie them loosely with the help of *sutli*.

Check Your Progress

A. Fill in the Blanks

1. Excess of nutrient amount in soil can lead to.....
2. Removal of all the side shoots emerging from the base of the plant is called as.....
3. The art of clipping and shearing various types of plants into various artistic shapes is known as.....
4. The first step in re-potting is.....

5. Act of applying a 5-10 cm thick layer of covering material on the ground surface around the growing plants is called as…….

B. Multiple Choice Questions

1. Hanging garden is at

(a) Buddha Jayanti Park, New Delhi
(b) Rock Garden Chandigarh,
(c) Kamla Nehru Park, Bombay
(d) None of these

2. …….helps the plants to grow straight

(a) Staking
(b) Pruning
(c) Both a & b
(d) Pinching

3. Repotting is done when plants have become……

(a) Pot-bound
(b) Overgrown
(c) potting mixture become devoid of essential nutrients
(d) All of these

4. Deciduous house plants are planted in……

(a) December-January
(b) February-March
(c) June-July
(d) September-October

C. Subjective questions

1. Write in brief about potting and repotting of ornamental plants.
2. Describe principles, methods and objectives of pruning.
3. Write in brief about importance of weeding.
4. Write in detail about mulching and staking.

D. Match the Column A and B

Column A	**Column B**
1. Artistic shapes	a. Kamini
2. *Polyalthia longifolia*	b. Pinching
3. *Murraya paniculata*	c. Earthing up
4. Stopping	d. Topiary
5. Hilling up	e. Ashoka

Session 2: Integrated Insect-Pests Management

Insects are the organisms belonging to division *Insecta* of Animal kingdom, which bear three pairs of legs and two pair of wings. They have a segmented body divided into three main segments called head, thorax and abdomen. Insects have one pair of antennae. e.g. grasshopper, dragonfly, cockroach, butterfly, etc.

Some insects are useful for mankind and are called beneficial insects, e.g. honey bee and lac insects. Some insects are harmful to the crops and therefore are called insect-pests. e.g. lemon butterfly, moths, fruit borer, aphids, thrips, etc.

Better technical knowledge is required to prevent or control pests. Identification of pest, selection of proper pesticide with perfect dose, method and time of application are important skills in achieving better pest management.

Insect-pest control

Any operation like use of chemicals, biological control, cultural operations etc. that interferes with the life of insect-pests and makes it difficult for them to survive in the field or on the plants either by killing or by repelling them, so their population is reduced is known as insect-pest control. Various methods employed for the purpose are given below:

1- Cultural method

Tillage

Different stages like eggs, larvae and pupae of insect-pests survive deep in the soil. Ploughing during summer season exposes them to their natural enemies and hot sun.

Clean cultivation

Weeds and bunds of the garden beds are important places for insect-pests to hibernate. Cleaning of bunds and removing of weeds regularly can help to minimize pest population. Crop residues of previous crop must also be removed and destroyed by composting. Burning of this residue in the garden beds should be avoided to prevent loss of soil microflora and environmental pollution.

Isolation

Plants of same group or same families, if grown nearby increase the availability of host and this may increase the pest population. If crop is isolated at proper distance, the movement of pests from one field to another is avoided and so their control becomes easier.

Altering sowing or planting time

This is a very effective strategy where merely sowing/planting of the host plants a little earlier or later than the optimum time of planting ensures that host plants or their suitable stage is not available

Eradication of alternate hosts

Weeds or other plants which act as alternate hosts by harbouring the insect-pests in absence of the major host can be removed to break the chain of host availability and thereby control the pest population.

Removal of infested plant or parts

Removal and destruction of infested plants and/or their parts reduces population of pest in the field.

2- Physical methods

These methods are mostly useful in controlling the pests in intact environment like storage or greenhouse. 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 the pests.

Hand picking and destroying

The insects or their eggs can be killed by pressing the clustering parts with thumb and finger such as aphids, they may be handpicked and destroyed such as *Pyrilla* and feeding larvae of various lepidopterous pests.

3- Mechanical methods

Removal of infested parts and insect galleries is very useful in pest control.

Screening

Wire mesh protects crop from birds, moths and rodent attack.

Sticky bands

Ants, white ants, whiteflies, aphids and other tiny insects stick on the bands, so they die there without moving anywhere afterwards. These can be applied on bushes, shrubs and trees.

Light traps

Insects such as borers (pod and fruit) are attracted by light. Light traps with a source of light and kerosene or some pesticide solution at the base traps such insects and provides effective control.

Biological control of insect pests

Friendly insects, bacteria and fungi are used in biological control as bioagents. *Trichograma, Crysopa*, Damsel bug, red wheel bug, stink bug, big-eyed bug, ladybird beetle (*Epilachna*), tiger beetle, robber fly, orius bug, tachinid 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.*

Legislative method (Quarantine)

This method prevents introduction of new insect-pests from foreign countries from entering our country through the seeds, plants or media during import. In

1914, Government of India had passed a legislation called "Destructive Insect and Pest Act" to prevent introduction of insects and pests.

4- Chemical method

Use of chemicals to kill or repel the insect-pests to control their population below a threshold level comes under this method.

Chemical nature (formulation of insecticides)

Dust

This is a dry formulation of the insecticide with inert carrier. e.g. Fenvolerate 0.4 % *etc*.

Wettable Powder (WP), dispersible powder (DP)

These are dry formulations but can be applied with water, e.g. lamba cyhalothrim 10 WP, wettable sulphur.

Granules

These are dry formulations, but particle size is more than that found in powder. These are applied in soil, e.g. Cartap hydrochloride 4% G.

Emulsifiable concentrates (EC)

An emulsifiable concentrate (EC) formulation is a combination of an active ingredient dissolved in a water-immiscible solvent with emulsifiers. Most of the insecticides are available in this formulation, e.g. cholopyriphos 20 EC, imidacloprid or acetamiprid.

Water soluble concentrates (WSC)

These formulations are easily soluble in water and are thus easy to use, e.g. Indoxacarb WSC, Chlorantraniliprole WSC, *etc*.

Fumigants

These are available in liquid or cake form and produce fumes which are harmful to the insects, e.g. phosphine, ethyl dichloro and carbon tetra chloride mixture (3:1) mixture, EDCT mixture, *etc*.

Table 2.1: Insect-pests of common ornamentals

S.N.	Name of pest	Symptoms of damage	control
1.	Aphids	Aphids are sucking pests found in colonies. They suck the cell sap from the tender parts, e.g. shoot tips, new leaves, buds and flowers. Their infestation in large number makes the infested parts sticky and dirty, retards the growth and kills the plants slowly.	Regular application insecticide such as dimethoate (0.05%) or Thiamethoxam 0.5% OR imidacloprid 1 ml/4 lit of water is effective to control it.

		Crop affected such as rose, tuberose and chrysanthemum.	
02.	Two spotted mite (spider-mites or red spider mite)	Mites are so minute that these can be seen only through magnifying glass. These are sucking pests. Silvery spots are found initially at the infested site. Infested leaves turn grey or bronze, curl and drop off. Crop affected such as rose, chrysanthemum, tuberose and carnation.	Emamectin benzoate 5 SG 0.4 gm/lit of water or dicofol 18.5 EC @ 5 ml/ lit of water is effective to control it.
03	Thrips	Thrips live and feed inside the bloom and on tender leaves. Adults and nymphs suck plant sap from tender parts, floral buds and petals. It deforms the infected parts and showing silvery scratches. Crop affected such as rose, chrysanthemum and carnation.	Emamectin benzoate 5 SG @ 0.4 gm/l or dimethoate 30 EC @ 1.5 ml/l at the intervals of 10-15 days
04.	Moth	It is a most common pest of rose and many other ornamentals. Caterpillars are the larval stage of *Lepidopteran* insects, generally polyphagus, and feed on the leaves, bore the buds and other plant parts, and sometimes curl the leaves and live inside. Infestation results in chewing of leaves, floral buds and flowers (Fig. 2.4).	Contact or systemic insecticides will help to control. Profenophos 0.2 % is effective to control it.

		 **Fig. 2.4: Chewing and Cutting**	
05.	Leaf miners	These tiny and dark fly larvae are very serious pests of chrysanthemum where larvae keep on feeding by mining the leaves and their damage is seen on the surface as silvery irregular lining of the tunnels as these continue feeding the tissues by piercing the epidermis (Fig. 2.5).  **Fig. 2.5: Leaf minor**	Infested and fallen leaves should be collected and destroyed. In severe cases, the crop is sprayed with a systemic insecticide such as acephate @ 0.025% or imidacloprid 1ml/4 lit of water.
06.	Bud Borer	It is a serious pest which damages flowers, leaves and stems. Larvae bore into the flower buds and flowers and feed on them leaving holes on the body. Crop affected such as tuberose and carnation.	Application of neem oil 1% repels various stages of pest. Foliar sprays of emamectin benzoate at regular intervals controls borer damage. Profenophos 0.2 % is effective to control it.
07.	**Pumpkin beetles**	Beetles feed voraciously on the leaves and flowers, cut the tender	Dimethoate 30 EC 500 ml/ ha.

		shoots and make holes in plant tissues which may result in death or retardation of growth.	

Activities

Collection and identification of insect-pests of ornamental crops.

Materials Required: Storage cum display box, insect collecting hand net, killing jar, spreading board, all pins/paper pins of different sizes, naphthalene balls

Procedure:

- Collect the insect-pests from ornamental crops or collect insects aerially through insect collecting hand net.
- Kill the insects by putting them in killing jar.
- Keep the insects on the spreading board and pin them in a way that various body parts of the insects like mouth, wings, legs, etc. remain properly displayed.
- Store the pinned insects in the storage cum display box carefully and put naphthalene balls to discourage entry of other insects

Label the insects with common names and scientific names.

Check Your Progress

A. Fill in the blanks

1. Chewing and biting of tissues is the main damaging symptoms of .....
2. Insects, which bore in the plant parts and feed on the internal tissues are.....
3. Insects, which gets inserted in between upper and lower surface of the leaf by mining are known as .....
4. Caterpillars are the larval stage of ..... insects.
5. Tiger beetle, robber fly, orius bug, tachinid fly, fruit fly, spider, and mantids ..... over insect-pests and they are known as ..... insects.

B. Multiple Choice Questions

1. Malathion insecticide is available in ..... form

(a) Granule
(b) Powder
(c) Liquid

(d) All of these

2. Insect have a segmented body divided into main segment/s called
   (a) Head
   (b) Thorax
   (c)abdomen
   (d) all of these

3. "The Government of India passed legislation for "Destructive Insect- Pest Act" in the year .....
   (a) 1910
   (b) 1914
   (c) 1918
   (d) 1922

4. Caterpillars of cutworms are most active during
   (a) Morning
   (b) Afternoon
   (c) Evening
   (d) Night

C. Subjective questions

1. What is mechanical method of insect control?
2. Discuss in detail about chemical method of pest control in ornamental crops.
3. Describe the pest problems in chrysanthemum.
4. Write short notes on
   a. Sticky traps
   b. Fumigants
   c. Thrips

D. Match the Columns A and B

Column A	**Column B**
1. Dimethoate	a. Acephate
2. Acaricides	b. Polyphagus
3. Leaf minor	c. Liquid
4. Caterpillars	d. Kelthane

Session 3: Integrated Disease Management

Disease

Any abnormality occurring in a plant due to infection by a pathogen or any nutritional imbalance is called a disease. Plant diseases are caused by fungi, bacteria, virus, mycoplasma, nematodes or nutrient deficiency etc. It is the interaction between susceptible host and virulent pathogen in favourable environment, e.g. wilt, die-back, canker, etc. There are many pathogens which spread through various insects and such insects are called vectors or carriers.

1-Cultural methods

Tillage: Soil-borne fungi, bacteria and nematodes serving as source of severe infection, hibernate in the soil. When soil is ploughed, they get exposed to high temperature of sun. This reduces their population or activity within soil.

Field sanitation: Previous crop residues, weeds and bunds of the field may serve as major source of infection. Clean cultivation means removal of crop residues and keeping the bunds clean so that pathogens are minimized in the field. The fungi causing rusts and many others complete their life cycle on weeds which act as alternate hosts. Regular uprooting and destroying such alternate hosts disrupt the life cycle of the pathogen and thus prove an effective method of control.

Resistant varieties: Planting varieties resistant to a particular disease or pest does not provide a chance for pests or pathogens to survive beyond one crop cycle because of which infection is minimized drastically.

Alteration in sowing time: Manipulation of sowing time and selection of early or late varieties also dodges the pathogens. Spores of certain diseases as early blight, late blight appear at a particular time in the year and require particular stage of plant which is susceptible for infection by the pathogen. Thus, alteration in sowing time prevents occurrence of disease by making susceptible stage of plant unavailable for infection.

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

Crop density: High density of cop favours the incidence of many diseases since infections can move easily from diseased to healthy plants in a dense field due to the conducive microclimate. It is therefore desirable to plant the crop at proper spacing which also improves air circulation in the plants and hence checks disease occurrence.

Mechanical methods of controlling diseases and vectors

It includes uprooting or pruning of diseased plants or parts so that infected material is not transmitted from diseased source to healthy one. Training and

staking the crop facilitate the 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

When some living organisms (parasites or predators such as birds, rodents) or certain plant products are used to control the pests of a crop, it is called bio-pesticide and the method is known as bio-control or biological control.

Antagonism: The mechanism of limiting or controlling the growth of micro-organism through another micro-organism is called antagonism and the organism used as controlling agent is called antagonist. This is most common method adopted nowadays as a biological control against many soil-borne diseases. Fungi *Trichoderma harzianum* and *T. viride*, and bacterium *Bacillus subtilis* have antagonistic properties against many fungi causing wilt and rot.

Chemical control

Fungicides

Use of chemicals called fungicides may protect the plants from fungal infection or may prove lethal to the pathogen. Fungicides according to their movement in the plant system are of two types ~ systemic fungicides: which on application on plants get dissolved in cell sap and are effectively translocated to whole system of plant irrespective of place of application (Benlate, Calixin, Carbendazim, Demosan, Ridomil, Sten 50, Thiabendazole, Tilt, *etc.*) and contact fungicides: whose action on plants is restricted to the area of application (sulphur, mancozeb, Zineb, Rovral, *etc).*

Fungicide application

Soil drenching

In case of soil-borne infection of fungi (wilt, damping off, root rot), the fungicide should be applied to the soil. Such fungicides are carbendazim, formaldehyde *etc.*

Seed treatment

To avoid infection from the soil as well as through the seed (anthracnose, dieback, downy mildew, *etc.*), seed treatment is recommended. Generally, seeds are treated @ 2.0-2.5 g fungicide/kg of seed. Seed dressing drum or earthen pitcher can be used for treating the seeds. Fungicides used for seed treatment are Ridomil, Vitavax, etc.

Pasting on affected plant parts

In case of gummosis, the affected parts such as stem is pasted with Bordeaux paste.

Foliar application

Aerial parts affected by foliar diseases can be controlled through foliar sprays or dusting of the fungicidal formulations. Specialized dusters or sprayers are available for treatment. Generally, fungicides are sprayed with compatible insecticides, so it reduces the cost of application. These fungicides are sulphur, copper oxychloride, mancozeb, Vitavax, *etc*.

Dip method

In this method, cuttings are dipped in the fungicidal solution for certain period before planting.

Integrated disease management (IDM)

It is the integration of the different methods used for avoiding and controlling the diseases. In this case, among all the methods, only the most useful methods of control are adopted to keep the pathogenic population under control or below the significant level. It includes adoption of preventive as well as control measures, which are eco-friendly as well as economical to the farmers**.**

Important diseases of ornamental crops

S.N.	Name of disease	Symptoms of disease	Control
01.	Damping off	Disease occurred at nursery stage of ornamental and vegetable crops. Infects the seedlings at collar region. Due to decaying of the collar portion the seedlings become collapse. (Fig.2.6)  **Fig.2.6: Damping off**	Sterilization of nursery bed by formalin gives protection against this disease. Soil solarisation is also found effective. Metalaxyl – MZ-72 is used as soil drenching 0.2 % or seed treatment 0.1 %.
02.	Wilt	Symptoms appear first on the lower leaves which turn yellow and the petioles drop. The affected plants turn yellow and dry. Crop affected such as chrysanthemum, carnation, gladiolus and marigold. (Fig.2.7)	Proper irrigation with improved drainage facilities, proper sanitation of the field, and carbendazim 1.5 gm/kg of seed are the measures

		 **Fig.2.7: Verticillium wilt of Sunflower**	applicable to avoid its infection.
03.	Powdery Mildew	Grey white powdery spots appear on the leaves, twigs, blossom and fruits. These spots coalesce to develop bigger patches. Affected part dries and turns black. Crop affected such as rose, chrysanthemum and marigold. (Fig.2.8)  **Fig.2.8: Powdery mildew**	Sulphur dusting or spraying wettable sulphur (0.2%) is recommended. caraxin or kerathane or carbendazim 0.1% can be used @12-15 days interval in such cases.
04.	Downy mildew	White to purple growth of the fungus appears on the lower surface of the leaves along the stem, and the pathogen spreads through wind and rain. Chlorotic blotches with necrotic spots appear on the upper surface of the leaves just above the downy growth. when the flower buds get infected, these become malformed and fail to open. Rose affected by this disease.	The disease can be controlled by spraying Fosetyl –A1 or metalaxyl MZ 0.15%.
05.	Canker	It is a very serious bacterial disease. The canker lesions are seen as water soaked-spots, which turn brown and become woody and corky.	Spraying 1% Bordeaux mixture on new growth or application of 500 ppm streptocycline + copper oxy chloride (COC) 0.3% is recommended.

06.	Blight	This is a very serious fungal disease. The term blight means burnt appearance. Brown to black spots appears on the leaves and the spots which coalesce to form bigger patches resulting in yellowing and drying of leaves and stem. Crop affected such as chrysanthemum tuberose, carnation, gladiolus and marigold.	Spray of the crop with 0.1% or 0.15% carbendazim + mancozeb 1.5 gm/lit water is effective control for the disease.
07.	Rust	Black, brown, reddish or bright orange pustules appear on both sides of leaves which expand to larger spots. Infected leaves fall off prematurely and stems are likely to wither. Rose affected by this disease. (Fig.2.9)  **Fig.2.9: Rust of Rose**	Crop should be sprayed with neem oil or oxycarboxin, Triadimefon 50%), zineb 0.3 % to control this malady.
08.	Leaf curl	It is a serious viral disease which becomes more severe during rainy season. The main symptoms observed are swelling, puckering and curling of the leaves and growth of the plant is stunted. Virus is spread by insect-vector whitefly. (Fig.2.10)  **Fig.2.10: Leaf curl**	Root dip treatment with imidacloprid17.8 % SL @ 0.5 ml/lit of water is effective to control it. spraying of dimethoate 0.05% For vector control.
09.	Mosaic	It is a viral disease in which leaves are covered with alternating yellow and green spots and broken lines. (Fig.2.11)	Use of healthy planting material and clean tools for

		 **Fig.2.11: Rose Mosaic**	propagation prevents infection. Imidacloprid 1ml/4 lit of water is effective to control it.
10.	Dieback	Drying of infected plant starts from top and continues downward, the pathogen entering through wounds or pruned ends. This causes severe defoliation of the top branches. Silvery coating with some black bodies are observed along with drying towards the base of the plant and in severe case, whole plant dies.	Infected branches removed. Bordeaux paste should be applied on pruned branches and wounds or copper oxychloride 0.3% spray is effective to control it. Difenoconazole 25 EC @ 1 gm/lit of water spray is effective to control it.
11.	Basal rot	Rotted stem parts exhibit circular small dark brown wart-like bodies with white cottony growth on basal region of the stem.	Infected plants should be removed along with soil and the plants are drenched with carbendazim before start of the monsoon. Metalaxyl MZ 0.15% is also effective to control it.

Activities

Identify various diseases of garden plants.

Materials Required: Herbarium file, pen, pencil and garden plants.

Procedure:

- Make a visit to field and see their overall appearance of plants.
- Collect the diseased samples and bring them to the laboratory.
- Make a herbarium file of diseased samples of ornamental plants.
- Identify the disease and label them in the herbarium file mentioning name of the disease along with the host plant and its part.

Check Your Progress

A. Fill in the Blanks

1. A disease of the nursery causing death of seedlings is known as……
2. A plant with lower leaf yellowing together with drying and dying due to the infestation of …… disease.
3. A disease with white powdery spots on all parts of the plants is called ……disease.
4. Leaf curl is a…… disease.
5. To avoid infection from the soil as well as seeds, the easiest method is ……

B. Multiple Choice Questions

1. When some living organisms or plant products are used to control the pests of crop, it is called……

   a) Weedicide
   b) Fungicide
   c) Pesticides
   d) Biopesticide

2. The integration of all the methods to avoid and control disease is known as ……

   a) Pest management
   b) Integrated pest management
   c) Disease management
   d) Integrated disease management

3. Viral disease is transmitted by ……

   a) Air
   b) Insect vector
   c) Soil
   d) Water

4. Blight is a……disease

a) Fungal
b) Bacterial
c) Virus
d) MLOs

C. Subjective questions

1. Write on the different methods of integrated disease control?
2. What are bio-pesticides? Give examples.
3. What are fungicides, how they are used for disease control?
4. Explain the different methods of control of viral disease?
5. Write short notes on (any three)
   a. Damping off
   b. Wilt
   c. Powdery mildew
   d. Canker

D. Match the Column A and B

Column A	**Column B**
1. Bio control	a. Water soaked-spots
2. Vector	b. Trichoderma
3. Leaf spot	c. Yellow to orange pustules
4. Rust	d. Insect
5. Canker lesions	e. Mancozeb

Session 4: Weed Management

What is a weed?

An undesirable plant in the field which is responsible for economic losses to the human is called a weed. Weeds appear suddenly in the field without any planting or sowing. Weed-propagules remain viable for long time and survive in the field even under odd conditions. Weeds may have annual, biennial or perennial life cycle. These can be reproduced by seeds or through vegetative means such as bulbs, corms, rhizomes or tubers. Weeds are harmful as these compete with main crop for nutrients, water, light and space and badly affect the growth and production of the main crop. Some weeds like carrot grass (*Parthenium hysterophorus*) can cause allergic reaction in human beings, besides acting as alternate hosts for many stages of insect-pests and diseases. These may also

produce certain toxins and chemicals that are harmful for the main crop as well as to humans and animals in the vicinity. They occupy land, spread fast and hence require regular eradication and spoil the aesthetic look of the garden. It is best to remove or kill weeds as early as possible. However, weeds should not be allowed to flower and set fruits or seeds.

Monocot weeds

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.

Dicot weeds

They have taproot system with broad leaves, veins on leaves are netted and produce flowers.

Sedges

Sedges have hard triangular stem and look like the grass. The leaves extend from each side of the stem in 3 directions. Sedges have sharp edges.

Common weeds of ornamental crops

Annual weeds: These weeds complete their life cycle in one season or one year. Crab Grass, Lamb's Quarters (*Chenopodium album*), Goosefoot (*kharbathua*; *Chenopodium murale*), Crowfoot Grass, Sandbur, Blue Grass, Alexander Grass, Basket Grass, *etc*. Broad-leaved annual weeds are *Drymaria, Phyllanthus*, pusley, *etc*.

Biennial weeds: These weeds complete their life cycle in two seasons or more than one year. Biennial weeds are Cudweed, Wild Onion, Wild Garlic, *etc*.

Perennial weeds: These weeds complete their life cycle in more than two years. Yellow Nutsedge (*Cyperus esculentus*), Purple Nutsedge (*C. rotundus*), Nutsedge (*C. iria*), Bermuda Grass (Devil/Doob Grass; *Cynodon dactylon*), Johnson Grass (*Sorghum halepense*), Torpedo Grass, Pennywort, Red Sorrel, Oxalis, Wood Sorrel, Congress Grass (*Parthenium* sp.), *etc*.

Fig.2.12: *Chenopodium album* (Bathua)

Fig.2.13: *Boerhavia diffusa*(Biskhapara)

Fig.2.14: *Cyprus* spp. (Motha)

Fig.2.15: *Commelina benghalensis.* (Kankawa)

Fig.2.16: *Phyllanthus niruri* (Hazadaan)

Fig.2.17: *Sorghum halepense* (Johnson grass)

Weed control

Exclusion of weeds: Weed seeds in seed lot, weedy stalks, weed residues in the soil, manure, farm yard waste and neglected field bunds are important sources of the weeds in the field. These sources, if inhibited or controlled, prevent introduction of the weeds in the field to a major extent. Use of pre-emergence herbicides help in this cause. Clean cultivation, field sanitation and regular cleaning of the bunds can help to check the spread of weeds. Weed seeds may be attached to weeding implements when used for removal of weeds which too cause the introduction of weeds. Maintenance of soil pH and fertility and drainage also reduces weed population. Weed seeds are light in weight and can easily be disseminated through wind and water. Such instances should be monitored and timely control measures if adopted can help to prevent weed introduction.

Solarization: It is the method of increasing soil temperature through absorption of sunlight, which destroys the seeds and other propagules of weeds. Solarization is done in the hot days of May and June by covering wet soil with transparent polythene during extreme summer for 4 to 6 weeks. The soil temperature may reach up to 40-55^{O}C depending upon the intensity of sunlight. Many annual weeds can be controlled by this method.

Germination and destruction of weeds: Before planting, the new field where a crop is already reaching to the harvesting stage, the field is irrigated to promote the weed seed to germinate by the time of planting. At seedling stage, the weeds are eradicated mechanically or by spray of herbicides. This process is repeated two to three times before planting the main crop. This brings down the weed population drastically in the field.

Growing cover crops: In this method, annuals are grown in between the rows of the main crop and on bunds of the field. Due to this, weeds are unable to get space and light to grow. This cover crop serves as live mulch in between the rows of the main crop. Sometimes cover crop is sprayed with herbicides and allowed to dry at the same place.

Mowing the weeds: Mowing consists of superficial trimming of succulent and herbaceous weeds. This inhibits the formation of seeds by the weeds. It should be followed by other methods of weed control otherwise it spreads branching of perennials, so low growing weeds become a problem.

Transplanting the crop: Cultivation of crop by transplanting 4-6 weeks old seedlings establishes the crop fast in the field which check the weed population to a great extent.

Pulling out the weeds: Pulling of the weeds in between the rows of the crop is very old method of eradicating weeds. This facilitates the loosening of soil and improves its drainage and aeration. Weeds are uprooted by pulling it by hands from moist soil along with roots or by using the hoes and sickles.

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

Chemical control: Labour being uneconomical, one resorts to intensified use of chemicals in controlling the weeds in ornamentals which is economical. A wide range of pre-emergence, post-emergence, selective and non-selective herbicides are very common in use to control the weeds.

Biological control

- Living organisms such as fungi, bacteria and insects are used to control weed population. Such herbicides are broadly known as bio-herbicides. When fungal spores or fungi are used to control the weeds, this is known as myco herbicide i.e. *Phythopthora* sp., *Colletotrichum* sp. and *Bipolaris*sp. are in use as myco-herbicide.
- 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, and eats 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 very limited. Very few host specific bio-agents are available at present.

Types of herbicides

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 the 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 to control perennial weeds. Pre-plant herbicides include K-pam, metam sodium, pelargonic acid, *etc.*

Pre-emergence herbicides: This is another group of herbicides which attack the weeds at seedling stage. These herbicides are generally selective, i.e. safest for the crop. These are applied to soil after removing the existing weeds. Pre-emergence herbicides must be applied before the germination of weed seeds. Flumioxazin, Isoxaben, Napropamide, Oryzalin, Oxadiazon, oxyfluorfen, Prodiamine and Trifluralin are included in this group.

Post-emergence herbicides: These are applied after weeds have emerged. These are very selective and control only a narrow range of weed species. Fluazifop-p-butyl and Sethoxydim control most annual grasses and Clethodim can control annual bluegrass as well as other grasses. Products containing the phenoxy group of herbicides, such as 2, 4-D, will selectively control broadleaved weeds. Non-selective herbicides are pelargonic acid, and the plant oils such as eugenol. Post-emergence herbicides are applied at seedling stage of weeds.

Selective herbicides: These are the herbicides used against specific group of weeds and do not prove harmful for other crops. Oryzalin Trifluralin, *etc.*, 2,4,5-T, 2,4–D, *etc.* kill broadleaved weeds but do not harm the monocots, while (*fluazifop*-p-butyl) controls monocot weeds and not the broadleaved ones.

Non-selective: These are the herbicides that prove lethal to almost all monocots and dicots that come in their contact, e.g. triclopyr.

Application of herbicides

Success of the weed control depends upon the method of application of herbicides. Application of herbicide accurately and in measured quantity is as important as its selection different equipment are used for application of herbicides according to formulation and area to be covered. On small holdings or in greenhouse, it can be applied through backpack hand pump sprayer or duster. In large nurseries, over-the-top sprayers to cover full beds may be best. 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. Granular herbicides can be spread by the drop-type or side-throw-type of spreader.

Commonly used herbicides

Pre-emergence

Technical name	**Effective against**
Bensulide	Annual grasses
Naproamide	Annual grasses
Prodiamine	Annual grasses
Oryzalin	Annual grasses, selective
Trifluralin	Annual grasses
Dithiopyr	Annual grasses
Metolachlor	Sedge, annual grass
Oxyfluorfen	Broad-leaved weeds
Oxyfluorfen + Oryzalin	Broad-leaved weeds
Oxadiazon	Broad-leaved weeds
Oxadiazon+ Prodiamine	Broad-leaved weeds and annual grasses
Oxadiazon + Oxyfluorfen	Annual grasses
Isoxaben	Broad-leaved weeds
Isoxaben+ trifluralin	Broad-leaved weeds
Dichlobenil	Broad-leaved, perennial

Post-emergence (non-selective)

Technical name

Sethoxydim	Annual grasses
Clethodim	Annual grasses, blue grasses
Glufosinate	Annual grasses, non-selective

Integrated weed management (IWM)

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

Activities

Visit the field and collect the weed species, identify them and prepare a herbarium.

Materials Required: Herbarium file, pen, pencil and weeds.

Procedure:

- Make a visit to fields and observe weed growth
- Collect the weed samples and bring them to the laboratory.
- Make a herbarium file of the weed samples.
- Identify the weeds, and label them in the herbarium file mentioning botanical name of the weeds along with the crop in which it is found.

Check Your Progress

A. Fill in Blanks

1. Weeds act as alternate host for ……and ……
2. Most of the grasses are comes under as …… weeds.
3. The weeds with taproot system and broad leaves are known as ……
4. The weeds with life cycle for two seasons are known as…… weeds.
5. Group of herbicides which, attack the weeds at seedling stage are known as ……

B. Multiple Choice Questions

1. Bermuda grass (doob grass) is a/an

(a) Annual weed
(b) Biennial weed

(c) Perennial weed
(d) None of these

2. Solarization is done in the months of .....

(a) February-March
(b) November-December
(c) August-September
(d) May-June

3. Crops suitable for growing as cover crops are.....

(a) Annual
(b) Biennial
(c) Perennial
(d) All of these

4. Living organisms when used to control weed population are known as.

(a) Bio-fungicides
(b) Bio-pesticides
(c) Bio-herbicides
(d) None of these

5. Prodiamine is a .....

(a) Pre-emergence herbicide
(b) Post-emergence herbicides
(c) Pre-plant herbicides
(d) None of these

C. Subjective Questions

1. Explain integrated weed management?
2. Explain the methods of application of herbicides?
3. What are the different types of herbicides? Explain with examples of each?
4. Why is weed control at appropriate time important for higher productivity?
5. Write Short notes on
   a. Mulching for weed control.
   b. Post-emergence herbicides.
   c. Exclusion of weeds.

D. Match the Column A and B

Column A	**Column B**
1. Glufosinate	a. Broadleaved weeds
2. Johnson grass	b. Post-emergence
3. 2,4–D	c. Pre-emergence
4. Oxydiazon	d. *Sorghum halepense*

Module 3
Establishment and Maintenance of a Lawn

Module Overview

A lawn can be defined as the green carpet for a landscape using grasses. It is the basic feature of any landscape. Any garden without a lawn is not considered complete. Lawn has multipurpose uses:

a. Provides a place for taking rest after tiring job of the day.
b. Holding parties, social functions.
c. Spending leisure time either alone or with family.
d. A place for calm and peace.
e. Moderates the surrounding temperature.
f. Enhances the beauty and utility of a residence or any official or private building.

A well-maintained lawn is a matter of pride to any homeowner and it also provides a pleasing background for herbaceous borders as well as a specimen tree or a shrub. Due to so many virtues, it is rightly called “Heart of a landscape”.

Learning Outcomes

After completing this module, you will be able to:

- Describe the steps involved in the establishment of a lawn, including site preparation, soil testing, and selection of appropriate grass species.
- Explain the best practices for maintaining a healthy lawn, such as mowing, watering, fertilization, and pest management.
- Identify common lawn problems and their solutions, ensuring long-term health and aesthetics of the lawn.

What is a lawn?

Lawn is a well-maintained green carpeted area of prostrate growing grasses at an appropriate place meant for enjoyment, playing and sports. It may be a part of the garden or any space. It makes the surrounding beautiful and supplies oxygen to human beings besides checking the runoff of the rainwater.

Characteristics of lawn grass

- It should be easy to establish
- It should grow quickly and be able to withstand frequent mowing.

- It should be soft.
- It should look fresh and green throughout the year.
- It should not be patchy.
- The grass should be resistant to frost and drought.
- It should be free from attack of pests and diseases.

Site

The lawn should preferably be established in the southern side of the building or the South-East or South-West of a building. Lawns do not grow well on North side due to lack of sunlight. Most of the grasses do not grow under the shadow of large trees. Therefore, the site should be free from of large trees since they cause shade and their dried leaves fall on the grass and make the lawn dirty besides serving as a source for disease and pest infestation.

Soil and its preparation

Soil should be well drained, fertile, sandy loam, levelled and rich in organic matter. The sub-soil should not retain moisture and must provide good drainage. Soil pH should be slightly acidic with a pH range of 5.6 - 6.8. Thus, the soil should be prepared suitably before planting of the lawn to ensure that it meets with the above criterion.

Manures and fertilizers

It is advisable not to add any manure if the soil is rich in organic matter, because organic manure may be a source of weed seeds and may be difficult to remove. Well-rotted farmyard manure @ 10 kg/m^2 is applied in poor soils along with supplementation with bone meal 8kg/100m^2. A thick layer of manure, compost and leaf mould is added and then mixed well to a depth of 15-20 cm in soil. 10-20 kg of super phosphate for every 30 m^2 of the area is added. Also, a mixture of 4:12:4 of NPK should be given @ 7-12 kg/30m^2.

Trenching and digging:

The digging operation should be done by trenching method to dig to the desired depth. To ensure this, a trench of 60 cm deep and 45 cm wide is dug out at one end of a site along with its entire length and the soil is kept outside of the lawn area. Rest of the area is dug out in the same manner. The soil removed from the freshly dug trench goes into the preceding trench. During digging, the clods are broken, and the soil is thoroughly pulverized. If the soil is too acidic, then 500 g/m^2 grounded limestone should be added.

Levelling: Levelling of soil is important for the success of a lawn making. Levelling of soil can be done by

1. Visual observation
2. Flooding the area
3. Laser level instrument
4. Stretching the rope in between pegs and observe.

Selection of lawn grass

The most suitable grass for most part of India is the Doob/Bermuda Grass/ Bahama Grass/Devil's Grass or Durba Grass (*Cynodon dactylon*). This grass thrives well under hot, sunny weather but will not grow under shade. Some common grasses which are also grown in lawns in India are given below Table (3.1).

Table 3.1: Lawn grasses for most common use

Scientific name	**Common name**	**Leaf characters**	**Adaptability**
Cynodon dactylon	Bermuda Grass, Doob Grass	Leaf blades 2-4 mm wide, stolons present	Most versatile lawn grass, heat and drought tolerant.
Zoysia japonica	Japanese Lawn Grass, Korean Lawn Grass, Manila Lawn Grass	Leaf blades 1-3 mm wide, leaf margin smooth	Slow growth rate, drought and salinity tolerant.
Axonopus fissifolius	Carpet Grass	Leaf blades 4-6 mm wide, coarse textured, light green in colour	Drought tolerant, suitable for acidic soils.
Paspalum notatum	Bahia Grass	Leaf blades are 4-10 mm wide, short scaly	Seashores, salty areas.

		rhizomes and dark green leaves	
Agrostis alba var. *stolonif*era	Redtop Bent, Creeping Bent Grass, Carpet Bent Grass	Its habitat is aquatic, terrestrial wetlands. It produces prostrate stems i.e. instead of growing erect; its stems lie upon or just above the ground. Stem length and leaf blades length is 0.4 - 1.0 m and 2-10 cm, respectively. Its panicle (flower cluster) grows up to 40 cm in height.	This grass is highly suitable for hills.

Method of lawn raising

A lawn can be established any time in the year, if irrigation facilities are available. However, for raising a lawn through seed sowing, it is advisable to sow lawn grass seeds after one or two monsoon showers while the grass roots are planted on the arrival of monsoon. Different methods for establishing a lawn are through

(a) seeding

(b) dibbling (transplanting)

(c) turfing and

(d) turf plastering.

(a) Seeding: Seeds should be free from other weed seeds. 250 g seed of Doob Grass is mixed with 4 to 5 kg of finely sieved soil and broadcast evenly in 100 m^2 prepared area of land. Soil is raked slightly for covering the seeds. Water is sprinkled daily with a fine nozzle sprinkler.

(b) Dibbling: Raising a lawn through this method takes the longest time for lawn establishment among the various methods. In this method, well matured rooted/unrooted grass cuttings are used for raising a lawn. These cuttings can be obtained from established lawn or from nearby nursery. Dibble (transplant) cuttings 5 cm apart on prepared area of soil mixture, press using a very light

roller over the surface and irrigate lightly at short intervals. The soil should be kept moist through frequent spraying of water for sprouting of grasses. The lawn is established in about four months through this method.

(c) Turfing: Turf is a rectangular, flat piece of earth of about 5 cm thickness with lawn grass growing thickly over it. The piece may be small squares or in rolls of small width (30 cm or so). These turf pieces/turfs of uniform size in thickness are laid close to each other in a well-prepared soil like bricks in a wall. If the turf is of unevenness thickness, some of the adhering soil is removed or some layer of soil added for oversized or undersized turfs, respectively before putting them in position beating with a wooden beater to make them firm. The grass is immediately watered copiously. Establishing a lawn through this method is the quickest method of lawn making but it is also the costliest.

(d) Turf plastering: A paste of garden soil, fresh cow dung and water is prepared which pieces of chopped up fresh rhizomes, stems or roots of grasses are mixed and spread uniformly on the surface of moist ground. The paste is covered with dry soil (2 cm thickness) to cover the planting material and watering is done regularly till the sprouting of grasses. This method is not suitable especially in dry and variable climate. (Fig. 3.1)

Fig. 3.1 Turf plastering

Procedure for establishing a lawn

- Select well-drained open and sunny site. Dig the ground with spade up to 30 cm depth.
- Break the clods and clean the ground by removing pebbles, stones, roots, weed rhizomes, etc.
- If required soil may be sieved through a wire mesh.
- Apply well rotten cow dung/FYM @ 5-10 kg/m^2 and single superphosphate or bone-meal @ 8 kg per 100 m^2 in the soil uniformly and mix thoroughly.
- Level the ground with the help of wooden plank.

- Flood the ground for firming the soil.
- Keep it weeds free with constant weeding.
- Observe the depressions and do fine levelling with leveller
- Give a gentle and gradual slope (3%) towards the sides of the lawn with the centre slightly raised.
- Select appropriate grass according to site.
- Plant grass by dibbling/turfing method.
- Irrigate the lawn at regular intervals.
- Do light rolling after 3 to 4 weeks.
- Cut the grass after 5-7 weeks with the help of scythe lawn mower.
- Remove the weeds regularly through weeding.

Precautions

- Avoid shady place for lawn establishment.
- Heavy soil may be amended up to 15 to 20 cm depth by incorporating well drained sandy loam soil.
- Raise the lawn 5 to 10 cm above the ground level for providing effective and easy drainage of excess water.

Diseases and Insect-Pests

Diseases

Brown patch disease (*Rhizoctonia* sp.): It occurs at the end of growing season, more serious being in case of those species having fine sward, *vis-à-vis* overfed with nitrogen. The first sign appears in the form of small, brown and circular patches about 10 cm in diameter, afterwards pink or white mould covers the grass which makes the grass slimy with eventual death. Carbendazim is very effective.

***Corticium* patch disease:** This disease usually appears during summer and may continue until autumn, though grass is not killed. The grasses give a bleached look with small pink-branched needles of the fungus developing on the sheaths and blades, most serious being on fescue grasses. Ordinarily, nitrogenous fertilizer application improves such lawns but in severe cases, Bordeaux mixture should be applied.

Fairy ring disease: It is the most important lawn disease. It is a ring type of patch formation caused due to infection of *Marasmius oreades* which feeds on the organic matter in the soil and releases nitrate as a waste product which is taken by nearby growing grasses where growth is accelerated and the grass becomes darker and so the green rings are formed, and the rings are two, one inner and the other outer whereas in between there is dead grass. Death of the grass occurs due to soil being full of fungal mycelium which hinders water

penetration, so grasses die due to creation of drought conditions. Bordeax mixture (4 kg copper sulphate: 4 kg hydrated lime: 50 litres of water) drenching will control this problem. Spray of azoxystrobin, flutolanil or triadimefon is also effective.

Red thread disease: (*Corticium fuciforme*) Disease appear when soil is nitrogen-deficient or poorly aerated. Its initial symptoms are formation of 7.5-8.0 cm diameter of patches of the reddish-brown to bleached grasses coupled with dark pink horn-like gelatinous growth out of the leaves which turn pale-pink and slightly fluffy. Its infection is visible from June to December but not afterwards. Good feeding schedule especially with sulphate of ammonia, improved drainage, proper aeration and use of carbendazim will control its infection.

Dollar spot (*Sclerotinia homoeocarpa*): It is common in fine-leaved bents and creeping fescues, *vis-a-vis* in compact lawn with heavy, compact and wet soils with high pH or alkaline soils and those treated with lime and its spread is favoured by poor turf growth and high humidity in summer though it is usually over by the winter. Middle of the leaf blades is also girdled due to its infection though leaf tips may remain green. It can be prevented by improving drainage *cum* soil aeration, spiking in autumn and through proper feeding and its control can be accomplished by applying carbendazim.

Curvularia blight: This blight causes leaves to become yellow, brown or black in fading lawns during hot and humid weathers. Too close mowing, thatching and non-aeration of lawn aggravate this problem. Spraying the lawn with mencozeb 0.2 per cent and carbendazim at 0.1-0.15 per cent controls this disease.

Insect-Pests

Earthworms (*Allolobophora chlorotica* and others): Earthworms are not harmful to the plants but their castings make the lawn unsightly, produce the slippery surface and brings about surface-unevenness which blunts the mower edges and hinders in its smooth working, *vis-a-vis* these often smear to leave a patch of bare soil which promote weed growth. Use of acidic fertilizers to maintain a low pH and avoiding application of lime. Spraying of imidacloprid during rainy to autumn season help to discourage this problem.

Cockchafer grubs: They are the curved larvae of the beetles feeding on the roots of the grass during summer and spring which can be controlled by applying Imidacloprid.

Termites and ants: They cause massive damage to lawn under dry soil conditions, feeding mainly on the roots but spreading further up to the leaf

blades and convert the lawn into the organic heap. Soil drenching with 0.05 per cent chlorpyriphos or 0.1 percent malathion before planting is an effective control.

Maintenance of lawn

- During first three months of planting, no mowing should be carried out using a lawn mower. Instead the grass may be cut manually using a scythe. Afterwards, the mowing should be carried out with lawn mower by adjusting the blade as close as possible to the ground so that first mowing is carried at 2 cm height for precocious branching. During winter, mowing should be carried out at monthly intervals while during summer and rainy seasons it should be done fortnightly.
- Rolling should also be carried out every month to level the land as due to earthworm or rat menace, the lawn becomes undulated. If the roller is spiked, it helps in aerating the soil.
- Cleaning the lawn with a broom after mowing and removal of fallen leaves from trees should be done as a routine.
- Irrigate the lawn twice in a week with a hose pipe and on alternate days with sprinkler during dry season.
- Prick out the weeds with roots as and when observed or regularly at fortnightly intervals.
- Top dress the lawn with manure (5 kg/m^2) or bone meal (8kg/100m^2) and fertilizers somewhere from November to February.
- Top dress the lawn with spray of urea @ 0.5 to 1% in the month of June and September.
- Irrigate the lawn after every fertilizer application.
- If the appearance is not satisfactory i.e. yellowing, patchy appearance and excess of weeds then the lawn should be scraped with the help of scraper/*Khurpi,*
- Rake the lawn to loosen the soil after scraping.
- Level and roll the lawn lightly after raking.
- A patchy place should be replaced by new turf or grass.
- Irrigate the lawn moderately after levelling and rolling. Do not leave irrigation pipe in the field after use.

Activities

Practice turfing method of lawn establishment.

Materials Required: Garden soil, open site, fresh cow dung, water and chopped up pieces of fresh stem, rhizomes or roots of grasses.

Procedure:

- Select well-drained open and sunny site. Dig the ground with spade up to 30 cm depth.
- Break the clods and clean the ground by removing pebbles, stones, roots, weed rhizomes, etc.
- Apply manure @ 5-10 kg/m^2 and single superphosphate or bone-meal @ 8 kg per 100 m^2 and NPK 4:12:4 (7-12/30m^2) in the soil uniformly and mix thoroughly.
- Level the ground with the help of wooden plank.
- Flood the ground for firming the soil.
- Make the plot weeds free.
- Observe the depressions and do fine levelling with leveller.
- Give a gentle and gradual slope towards the drainage source.
- Select appropriate grass according to requirement.
- Lay the patches of turf close to each other.

Check Your Progress

A. Fill in the Blanks

1. Quickest method of establishing the lawn is.....
2. Most suitable grass for lawn is.....
3. For lawn establishment, suitable soil is.....
4. The most important lawn disease is .....
5. Slowest method of establishing the lawn is.....

B. Multiple Choice Questions

1. Most tolerant lawn grass is

   (a) Cynodon dactylon
   (b) Paspalum
   (c) Agrostis
   (d) None of these

2. Most suitable lawn species for temperate region

   (a) Agrostis
   (b) Zoysia
   (c) *Axonopus*
   (d) None of these

3. Most suitable lawn species for seashores is .....

   (a) Paspalum notatum
   (b) Cynodon dactylon

(c) *Agrostis*
(d) None of these

4. The best situation for a lawn is the ..... side of a building

(a) Northern
(b) Eastern
(c) Southern
(d) Western

5. Common name of *Cynodon dactylon* is .....

(a) Bermuda grass
(b) Bahama grass
(c) Durba
(d) All of these

C. Subjective Questions

1. What is the importance of lawn?
2. What is purpose of mowing?
3. What are the different methods of lawn establishment?
4. How will you do care and maintenance of lawn?

D. Match the Column A and B

Column A	**Column B**
1. *Paspalum notatum*	**a.** *Marasmius oreades*
2. *Axonopus fissifolius*	**b.** Carpet bentgrass
3. *Agrostis*	**c.** Bahia grass
4. Fairy ring disease	**d.** *Sclerotinia homoeocarpa*
5. Dollar spot	**e.** Carpet grass

Module 4
Basic Landscape Designing And Garden Components

Module Overview

Man might have felt need for cool and shady places during summer and open and sunny situations during winter for taking rest after tiring job of hunting. As hunting was most convenient near water bodies, so he might have planted certain trees for shade there also for taking rest under them. This concept gave rise to landscape gardening. Man has always been attracted by natural objects like water bodies, mountains, rocks, moon, stars, sunrise, sunset, colourful plants, animals, bird, fish, etc.

It is the eternal desire of a man to make his living like that of paradise. This imaginary paradise has been created on the earth in the form of garden. Benefits of greenery in this universe especially in cities and towns are well established. Gardens are meant for recreation and these are considered as lungs of the cities. They facilitate outdoor Activities like playing of children, exercise, stress relieving, refreshing mind and body, boosting sagging spirits and reading/writing work in calm and tranquil atmosphere. People come close with nature and enjoy it as gardens attract birds and insects of different types which is a delight to the eyes. They also reflect the change in season e.g. falling leaves of a tree indicate one season while the growth of bushes indicates the rainy season. A garden can be made up of natural as well as manmade components.

Learning Outcomes

After completing this module, you will be able to:

- Describe the principles of landscaping, including design elements, plant selection, and the importance of landscaping in enhancing aesthetic, environmental, and functional aspects of an area.
- Explain various styles of gardening, such as formal, informal, and themed gardens, and understand their unique characteristics and historical significance.
- Discuss the benefits of landscaping and different gardening styles in terms of biodiversity, ecological balance, and human well-being.

Module Structure

- Session 1: Landscaping and its Importance
- Session 2: Styles of Gardening

Session 1: Landscaping and its Importance

Landscaping: An area on which it is possible to create a view or design is landscape. Landscaping is the art of beautifying a piece of land using garden designs, methods and plant materials. It is arranging the outdoor space for beauty and comfort. It may be paving a yard, constructing a deck, devising a sun- or windscreen, installing lights or building a tower over a garden corner. The professionals who design such plans are called landscape architects.

Importance

Landscaping has become an integral part of any building (home, office, playground, parks, hospitals, factories, educational institutes, religious places like temple, gurudwara, mosque, church, etc.) construction. Plants in the landscape include trees, shrubs, climbers, bedding plants, cacti and other succulents, orchids, bromeliads, foliage plants, annuals, biennials and perennials, bulbous plants and grasses. Ornamentals are formally displayed for public enjoyment in places such as arboratums, parks and botanical gardens which are designed to exhibit a large variety of plant types for the pleasure and education of visitors. Public areas such as malls, playgrounds, and cemeteries are places where plants are planted for specific purposes. In many societies, certain flowers are associated with specific social events.

Aims of landscaping

The objectives of landscaping are many and should be decided right in the beginning before initiating any landscaping project.

Beautification: Beautification is one of the important goals to highlight attractive areas or to divert attention of the visitors.

Privacy: The walled partition by front door, wall in front of a house or shrubbery border in front of a house creates privacy for the inmates of a house.

Comfort: Allowing one to stretch out to read on a shady place or sipping beverages in afternoon under a leafy arbour.

Safety and Convenience: These are the vital factors in landscape planning. Traffic patterns lead visitors clearly to the front door, so the paths and steps are lighted.

Flexibility: Also, the objective should be multifarious to use one object for some alternative works. One may opt for multipurpose object such as a bench whose seat can open for garden storage or a sandbox that can be covered to form a low dining table or a surface for container display.

Recreation: There must be provision for the court, volleyball children's playground, etc. that enhances a home environment.

Food Production: If space permits and also as per individual's choice, the garden may even be utilised by planting various types of vegetables, fruits and nut trees for self-use.

Entertaining: Also, if space permits, one can think for party in the lawn, and there, one can have dinner and other functions including wedding parties.

Ease of Maintenance: This is important as many gardeners appreciate the benefits of such labour saving and effective ideas as mulching, mowing strips, raised planting beds, watering systems and slow growing *cum* dwarf plants. Those plants are planted which require little care.

Principles of Landscaping

Broadly, there are four elements of design, *viz.*, axis or line, form, texture and colour; and seven principles of design, *viz.*, balance, rhythm, proportion, scale, focal point (also known as vista/accent), contrast and harmony.

A. Elements of Design

1. Axis and Lines

This element is applied in all aspects of landscape. This defines physical and/or visual movement in the garden. It enables viewers to view whole of the landscape and defines space. Landscaper draws the lines by forming patterns in a repetitive sequence through contrasting plant materials such as edges, ground covers and skyline being formed by planting the trees.

2. Form

It is a broad term showing two or three-dimensional structure and shape of an object or space. It is a line surrounding the mass, shape of shrubs or trees, areas of grass bound by edging, and the air space created by two plant materials set side by side, though all these components may have their own distinctive forms. However, the form of plants (upright, horizontal, weeping, oval, conical and round) dominate the design.

3. Texture

In the landscape, it is the feature *cum* structure, i.e. physical surface quality (shiny, dull, smooth or rough) of a plant and the size and arrangement of a plant's component parts (leaves, stems, branches and flowers), *vis-à-vis* the size, shape, texture and colour of sand, gravel and chips in relative terms with each other and by distance. It can be measured through senses of sight, touch and individual's perception.

4. Colour

Light is source of colour, and it consists of several visible wavelengths, each producing a characteristic colour. Colour is expressed only in presence of light and white colour is expressed through mixture of all the wavelengths while black in absence of light.

There are three primary colours *viz.*, red, blue and yellow which produce secondary colours like green (Blue + yellow), orange (yellow + red) and violet (red + blue). Tertiary colours *viz.*, red-violet, red-orange, yellow-green, yellow-orange, blue-violet and blue green are produced by mixing equal parts of primary and an adjacent secondary colour as shown in the colour wheel. Yellow, red and orange are warm, dominating and advancing colours as are associated with sun, fire and heat, respectively, and these bring feeling of excitement among the viewers. Blue and green are the cool colours and represent ice, sky and water, respectively. (Fig 4.1)

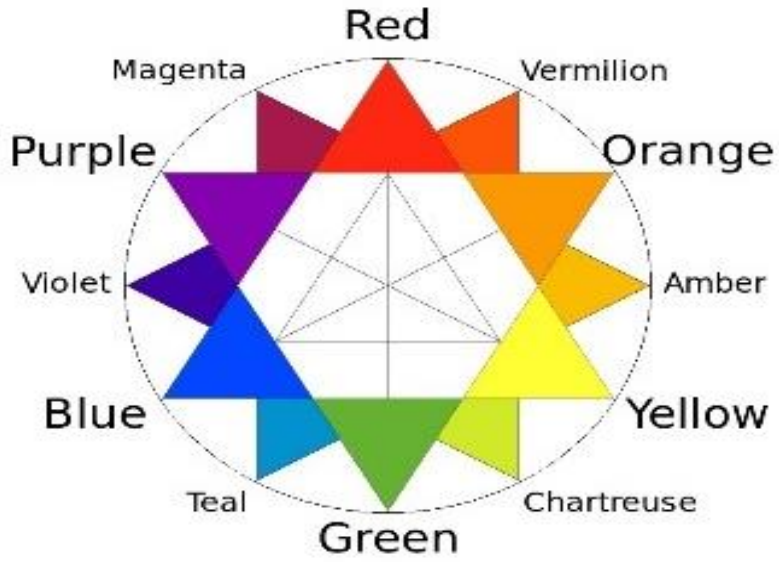


Fig 4.1: Colour wheel

B. Principles of Design:

1. Focal Point

It is the visual break in the sequence and flow of the landscape where eyes find something which engages the mind. It may be created through plants and structures with contrast in spacing between the plants, by grouping several plants together, running water and rustling leaves. It may also be created through various plantings in an area which may appear differently in different seasons as carpet beds with attractive blooms during spring and summer and the change in the leaf colours in trees and shrubs during autumn.

2. Proportion

In any design, proportion is the mathematical size relationships among the components and the landscape as a whole, i.e. planting close to the house should not be of trees but shrubs and that too in proportion to the height of the building.

3. Scale

Scale is a relative dimension. Different landscape elements have aesthetic appeal only if each one of them is in a proper scale else the beauty of the various designed landscape elements becomes ineffective. The large rivers, high mountains and rushing waterfalls are created on an elaborate scale in nature. Man, while copying them in his designed landscape, reduces them in scale and relates them to a size convenient to the landscaped area.

4. Balance

Balance is the equalization of visual weight from one area of a landscape composition to the other area though it is different in both types of gardens, i.e. formal and informal. Formal gardens have symmetrical balance (bi-lateral symmetry), i.e. the same type of things being repeated to either (both) side of an imaginary line so that there is equal visual weight on both the sides. On the other hand, informal gardens have asymmetrical balance. Proper balance by selecting appropriate colours should be done to create the desired effect.

5. Order and Unity

Order and unity depict the structure and organization of a garden through various design elements.

Order is the overall rhythmic and sequential organization, i.e. basic framework of a design composed by maintaining the balance between formal and free designs.

Unity is the congruous and harmonious relationship among all the characters (elements) in a design in a simple form so that it may appear picturesque, as complex use of components and materials gives the landscape a haphazard look.

6. Repetition

Repetition is the use of an element in a design more than once in order to maintain unity, establishing rhythm and sequence, and pulling whole of the design together.

7. Rhythm and Sequence

These denote continuity (motion) through dynamic and systematic movement of lines, textures and colours in a cohesive manner in the design. These can be created by repeating one or more of the elements such as pattern, form, texture, colour and any other design principle.

8. Interconnection

The various elements of design should look interrelated and in harmony with each other for imparting a picturesque look to the whole landscape.

Scope of Landscaping

Increase in urbanization, transit flow and improvement in infrastructure of the country has created a great scope for landscaping in India. Living standard of the people in this country has increased substantially leading to the development of large complexes and malls, apartments, hotels, hospitals, large premises of schools, colleges and universities, factories, foreign franchisees, industries and government offices, all of which undertake landscaping to create an aesthetic environment and attract more and more people. India is naturally blessed with the various landscapes of hills, riversides, lakes, forests etc. which can be easily landscaped to attract tourism including religious, educational and medical tourism.

It is essential to have a well landscaped countryside so that after returning to their native countries people carry a good impression of our country and contemplate visiting again. Landscaping can help keep the environment fresh and healthy by providing fresh oxygen and combating obnoxious gases apart from beautifying the area and awakening the people for maintaining cleanliness, sanitation and beauty in their surroundings.

Features of a Garden

Garden Wall: A garden wall is generally installed to prevent trespassing, infiltration and theft, a check for stray animals and to obstruct the unpleasant surrounding. However, the boundary wall around the garden should be of an appropriate height so that it does not kill the beauty of the garden. Climbers and creepers can be trained over such walls to hide the hard construction works and help to merge it with the landscape.

Fencing: In absence of boundary wall fencing becomes an important feature in a garden to protect it from outside interference and sometimes, even to protect some specific features inside the garden itself. This is of two types:

(a) Living fence: with fast-growing, thorny, plants, which may look charming e.g. Bougainvillea, Karonda, Casuarina, Thuja, Duranta, Lantana, Clerodendron, Bamboo, Aralia, *etc.* These require frequent training and pruning, so that beauty and shape is maintained.

(b) Non-living fence: Barbed wires, metal chain linked fence, plastic fence, bamboo poles, shade net, etc. These may be trained with beautiful climbers and trailers.

Gate: Whether the garden has demarcated boundary with walls or fences or is without such demarcation, an entrance is always a must. It should neither be too small or too large in size. The size of gate depends upon the size of garden and the crowd visiting the garden daily. Entrance gate should be quite attractive and at the roadside. Total appearance of the gate should be in harmony with the garden and an effort should be made to beautify the gate by covering with beautiful creepers and climbers.

Steps: Steps are necessary where the paths or roads go one level higher to the other or features which are situated at a higher level. The materials used for making steps should match with the plants. Normally cement, stones, brick or wood are used for making steps. Stepping should be broad and low-rising so that it remains comfortable while walking. Width should be such that two persons on both sides of the path can walk comfortably.

Roads and paths: Roads and paths are meant as approaches to move in the garden, but these should match with other garden features. Two-way paths are preferable. Roads are broader than the paths and used to transport the garden material to various sections of the garden. These should be flat, dry and pleasantly smooth for the visitors. Normally roads are 2 to 5 m wide and dressed in pieces of marble, tiles, gravels, paving stones and bricks. Shrubs and trees should be planted on both sides. Cement and concrete roads are preferred in a

garden. Light system should be there on the roads and paths for safety and visibility at night

Edge: Lining with hardy, perennial (sometimes even annuals), dwarf and compact plants along the paths, beds and borders is known as informal living edges, while with non-living materials such as stones or bricks is known as informal non-living edging. Suitable foliage edge plants are Alternanthera, Duranta, Coleus, Eupatorium, Iris, Pilea, etc. and suitable flowering edge plants are Amaryllis, Gerbera, Miniature Rose, Pansy, Perennial Verbena, etc.

Hedge: hedges are planted for separation of different parts within the garden, and for privacy at times serving as wall of the compound. They also separate various parts of the garden from each other. Sometimes they are also used to screen unsightly spots. Hedges are durable, woody and taller than edges. These should be self-protective, fast growing, dense hard to penetrate by animals, evergreen, amenable to frequent pruning, should have basal branching, dense and compact, long living, easy in multiplication and drought resistant. Suitable hedge plants are *Acalypha, Aralia, Bougainvillea, Casuarina, Clerodendron inerme, Dodonaea viscosa, Duranta, Ervatamia, Hibiscus rosa-sinensis, Ixora, Lawsonia, Murraya exotica, Tecoma gaudi-chaudi, Thuja,etc.*

Arches: Arches are semi-elliptical or rectangular metallic entrances made over cemented pillars or walls and covered *cum* with trained beautiful climbers such as *Adenocalymma alliaceum, Allamanda cathartica, Antigonon leptopus, Bougainvillea, Ipomoea horsfalliae, Jasminum* (climbing type)*, Passiflora, Petrea volubilis, Quisqualis indica, Rosa alba, R. lutea, R. wichuriana, Thumbergia grandiflora, T. mysorensis, Wisteria chinensis, etc.* It creates a link between road and landscape components. Width of arches is variably dependent upon width of roads and paths but in no way less than one metre.

Pergola: When series of arches are joined together, it is termed as pergola. Shade is provided by either covering the pergola with shading material or by training plants over it to create shade. It connects two garden parts with each other and is generally 2.5 metres high and at least one metre wide. It is always constructed over pathways in the garden. The framework for the pergola is usually constructed with iron wire, poles, bamboo, pipes, *etc.* over which the climbers and creepers are trained. It gives cooling effect during summer and protects the persons from piercing sun. The climbers and creepers suitable for pergolas are similar to those of arches. (Fig 4.2)

Fig 4.2: Pergola

Carpet bedding: Planting of dwarf herbaceous plants in a bed or series of beds according to a set design is known as carpet bedding. It looks quite charming if grown on slope or slanting land. Carpet bedding can be designed into various geometrical designs and shapes. Selected plants can be planted in such a way that it could be shaped according to the required design. Extra seedlings should be available to fill the gaps in the carpet bedding in case of any mortality. Suitable plants are Alternanthera, Cineraria, Coleus, Echeveria, Iris, Pilea, Portulaca, Senecio, *etc.*

Flower beds: It is a group planting of seasonal flowers at a sunny place in a formal or informal bed at short spacing. The beds may be of different sizes and geometrical shapes such as circular, rectangular, square and elliptical or asymmetrical, sometimes further beautified through edging. Plants suitable for flower beds are all flowering annuals *viz.,* Bellis, China Aster, Chrysanthemum, Cosmos, Gaillardia, Gerbera, Larkspur, Petunia, Poppy, Snapdragon, Sunflower, Tagetes (dwarf types), Zinnia, etc as well as bulbous plants. (Fig.4.3)

Fig.4.3: Flower bed

Shrubbery: Shrubbery can be defined as an area planted with shrubs and is an essential feature of any garden. Shrubs are easy to maintain, with beautiful flowers and/or attractive foliage. These display utmost beauty when planted along the paths or roads, around a lawn, inner side of fencing and at a corner of a garden. Shrubs with beautiful flowers are *Bougainvillea*, *Bauhinia*, *Ixora*, Lantana, *Nerium*, *etc.*; with attractive foliage are *Acalypha*, *Aralia*, *Croton*, *Duranta*, *Thuja*, *etc.*; and the shrubs producing attractive berries are Coffee, *Arbutus*, *Duranta*, Carissa, *etc.*

Rockery: It is gardening of ornamental plants in combination with rocks and stones for enjoying additional beauty at an open space. It would always be better using water-worn or local stones. One to two large boulders are kept in the centre and the smaller ones in the sides in natural manner creating soil pockets for rock plants. Those plants are used in the rockery, which are usually drought tolerant. Small zigzag pathway may serve as an approach to the top of the rock. The combination of rockery with a waterbody looks more charming. Suitable plants for rockery are *Opuntia ficus-indica* (prickly pear), Agave, Euphorbia, Kalanchoe, Senseveria, Aloe, *Polypodium*, *Nephrolepis exaltata* (sword fern), Calliandra, Cassia, Crossandra, Duranta, Jatropha, Juniper, Lantana, Thuja, Pedilanthus, Dracaena, Verbena, *Tradescantia* (wandering jew), Portulaca, *etc.*

Herbaceous Border: Long narrow beds containing various herbaceous plants are known as herbaceous border, which is an important feature of English garden. Taller plants are planted in the back, dwarf ones in the front and intermediate ones in the centre. Plants suitable for herbaceous border are *Angelonia*, *Canna*, *Catharanthus*, *Dianthus*, *Statice*, *Verbena*, etc. On the same

principles, the mixed borders are also made using plants such as herbaceous shrubs, bulbous plants and annuals such as *Acalypha,* African marigold, *Ageratum, Alternanthera,* China aster, crossandra, hollyhock, *Ixora*, *Lantana*, *Lagerstroemia*, *Nerium*, *Poinsettia*, Phlox, *Thunbergia*, *etc*.

Annual mixed border: It is like the herbaceous border but in this type of border, different types of flowering annuals are planted ~ taller ones in the back, smaller ones in the front and intermediate ones in the centre. Suitable plants are Candytuft, China Aster, Annual Chrysanthemum, Coreopsis, Marigold, Petunia, Salvia, Zinnia, Verbena, Ice Plant, Daisy, *etc*.

Lawn: Lawn is a well mown green carpet area of grasses for a landscape. It can be an area of its own or a part of the garden. This is created for a permanent greenery and to have healthy environment and is called heart of a landscape gardening Doob Grass (*Cynodon dactylon*) is the most commonly grown grass in different parts of the country. Lawn requires frequent and regular mowing, irrigation, feeding, spiking and other maintenance works.

Topiary: Topiary is an art of giving informal shape to the plants such as birds, animals, and formal shapes such as square, rectangular, triangular, globular, *etc*. The plants most suitable for topiary are *Clerodendron inerme*, *Duranta plumieri*, *Casuarina equisetifolia*, *Ficus* spp., *Vernonia elaeagnifolia*, *etc*.

Water garden: The art of using water in making water garden had been practiced in India since ancient times. Water gardens created in any tropical garden looks beautiful provided abundant fresh water. It may be formal (square or rectangular) and informal, i.e. teardrop shape, circular, egg-shaped, kidney-shaped and so on. This may be large puddle and small concrete type. The depth is usually 1 m though for marginal plants, it is roughly 25 cm deep. (Fig. 4.4) Plants for water garden can be grouped into following types:

(a) Surface flowering aquatics: American Lotus (*Nelumbo lutea*), Lotus or *kamal* (*N. nucifera*), Water Lily (*Nymphaea*), Golden club (*Orontium aquaticum*), Royal Water Lily (*Victoria amazonica*).

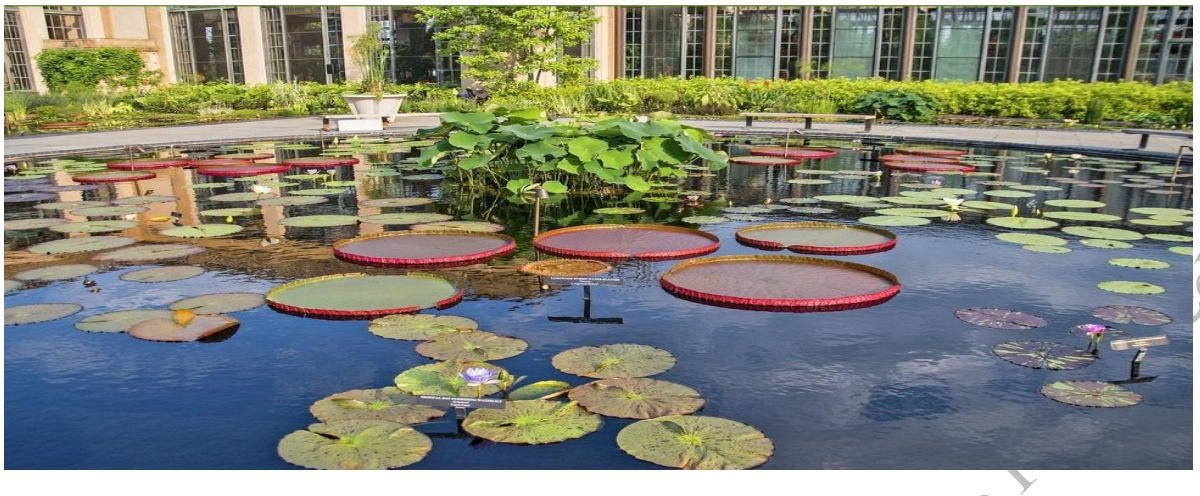


Fig. 4.4: Water garden

(b) Oxygenators: These are oxygenating plants which maintain hygiene and balance in a pool and therefore vital to any pool. Examples are *Antarctic water-Starwort* (*Callitriche autumnalis*), *Hornwort* (*Ceratophyllum submersum*), Canadian *Waterweed* (*Elodea canadensis*), *Common Water-Crowfoot* (*Ranunculus aquatilis*), Tapegrass (*Vallisneria spiralis*).

(c) Floating plants: These plants don't need to hold or grip of soil (anchorage) for their survival. Examples are Mosquito Fern (*Azolla caroliniana*), Duckweed (*Lemma minor*), Water Caltrop (*Trapa natans*).

(d) Marginal Plants: These plants keep their roots in shallow water and aerial parts above the surface. These are very hardy and outgrow pool size if their growth is not checked. Examples are bach (*Acorus calamus*), Marsh Calla (*Calla palustris*), Umbrella Palm (*Cyperus alternifolius*), Japanese Water Iris (*Iris laevigata*), Common Arrowhead (*Sagittaria sagittifolia*), etc.

Garden Adornments

Several adornments are to be provided in a garden, which add to the beauty of garden as well as pleasure and comfort of visitors. Garden adornment is different than garden feature but sometimes it is so arranged that they become the part of the garden feature.

Some important garden adornments

Fountain: In any type of garden, at least one fountain should be there to add beauty and to create pleasant atmosphere in the garden. This is an essential garden adornment in a public garden and also in a garden in front of home. Fountain should be at central portion in formal garden. The pipes used for making a fountain should be rust resistance.

Tubs and urns: Ornamental plants can be grown in tubs and urns indoor as well as outdoors for beautification purposes.

Bird bath: It is a bowl-shaped ornamental container which is filled with ample fresh water and kept at quite corners of the garden for inviting birds in the garden. Bird bath adds mobility and liveliness in the garden.

Seats: Seats are very essential to provide a place for visitors to sit and enjoy the landscape

Floral clock: It is electricity operated huge clock indicating time in seconds, minutes and hours. The machinery of the clock is concealed in an underneath chamber covered with ornamental plants or coloured photographs and above that the hands of clock are fitted on a dial frame.

Japanese Lanterns: Decorative Japanese lanterns should be placed near gates, beside streams, paths or pond.

Ornamental stones or rocks: Ornamental stones or rocks having different shapes and sizes should be placed on rockery or near ponds, along a stream and waterfalls or near the entrance.

Hanging baskets: They may be made up of steel rods and mounted in a various fashion with various sizes to hold the potted plants.

Statue: Statue of animals or any other artistic shape should be placed at suitable place.

Children park: Some area of garden should be reserved for making a children park,

Fish-ponds: Fish ponds may be centre of attraction in a garden as fishes bring mobility element and attract many people.

Maps and flow charts: Provision of suitable maps on the board, photographs or pictures helps the visitors to know the direction and location of various features of a garden.

Museum: A collection of knowledge-based articles neatly arranged and labelled may be of interest to many people. It should be placed at a proper place in a proper structure. Living creature can be included in this type of museum.

Landscaping of a home

Keeping all these principles in mind and considering growth habits, basic requirements of plants, the master plan should be prepared on the paper by pencil. Choice of owner is of equal importance in landscaping of home. The position of different plants and other components that are selected for

landscaping should be confirmed and marked in master plan by different colour pencils. (Fig. 4.5)

Fig. 4.5: Home landscaping

Landscaping of educational institutes

Landscaping of educational institute inculcates aesthetic sense to the new generation. Beautification of educational institutes helps in teaching subjects like botany and ornamental horticulture to students. Emphasis should be given to grow those plants, which require less maintenance.

Tall and dense trees should be selected for boundary. For boundary line planting, drooping ashok, *Eucalyptus*, Silver oak, Rain tree, etc. are suitable.

Flowering trees having flowering in different seasons like *Bauhinia purpurea, Bauhinia variegata*, *Cassia fistula*, *Delonix regia*, *Erythrina indica* are selected and should be planted in planned manner. Provision of a bird amidst the trees would attract birds which is educative to students. Medium or large flowering trees like Amaltas/Golden Shower Tree (*Cassia nodosa*), Flame Of The Forest/Dhak/Tesu/Palas (*Butea monosperma*) are planted in wide roads while small ones like Bottle Brush (*Callistemon lanceolatus*) and Kachnar/Orchid Tree (*Bauhinia variegata*) in the narrow roads/avenues. Narrow paths can be planted with small shrubs, either as hedge or edge plants.

The compound walls can be decorated by training climbers and creepers. *Bougainvillea* plants trained over the walls makes different look and they are hardy and flower throughout the year. Similarly, Golden Shower (*Pyrostegia venusta*) supported against a wall looks extremely beautiful when in full bloom during winter season. The lawn in playground enhances beauty but it requires regular maintenance. (Fig: 4.6)

Fig: 4.6: Landscaping of an educational institute

Industrial Landscaping

An industry is landscaped not only for its beautification, but also to combat various types of pollutants emanating from it. Therefore, the selection of plants should be judicious as they should not only look beautiful, but also combat pollution. Select hardy plants for the sites, where there are air polluting factories like smoke, dust and harmful chemicals emitting factories. The plants with high Air Pollution Tolerance Index (APTI) like *Eucalyptus, Casuarina equisetifolia*, silver oak, etc. should be planted in the vicinity of factory area to stop spread of smoke and dust. A buffer zone should be created by plating of trees between the factory and its residential colony to cut down pollution and noise level. Besides giving shade and cooling effect to the workers from the hot interior environment of the factory. Other garden elements like fountain, rockery, water pool, etc. could be incorporated for beautification. *Bougainvillea* are used round the year flowering as hardy plants in the vicinity of a factory. Establishing a lawn in the factory will further beautify the area and also arrest the dust.

Activities

Visit the campus area and collect the plant species, identify them and prepare an herbarium.

Materials Required: Herbarium file, DSLR camera, pen, pencil and plant samples.

Procedure:

- Make a visit to the campus area and observe various types of plants growing there.
- Take photograph the various types of plants present in the campus.

- Collect the plant samples and bring them to the laboratory.
- Make a herbarium file of the plant samples.
- Identify the plant samples and label them in the herbarium file mentioning botanical name of the plants along with its use in landscaping.

Check Your Progress

A. Fill in the Blanks

1. The pipes used for making a fountain should be.....resistant.
2. Beautification of educational institutes also helps in teaching certain subjects like ..... and ..... to students.
3. The most common grass used for lawn making in different parts of the country is.....
4. Bird bath adds ..... and ..... in the garden

B. Multiple Choice Questions

1. Long narrow bed containing various herbaceous plants are known as

(a) Shrubbery border
(b) Flower border
(c) Herbaceous border
(d) Rockery

2. Plants are used for making shrubbery border are

(a) Annual
(b) Biannual
(c) Perennial
(d) All of these.

3. Primary colour are

(a) Red orange blue
(b) Red blue yellow
(c) Yellow green orange
(d) Red violet yellow

4. Canadian *water weed* is a/an

(a) Oxygenator
(b) Floating plant
(c) Surface flowering aquatics
(d) Marginal plant

5. Normally roads are ..... wide in a garden
(a) 0.5 m
(b) 0.5-1m
(c) 1.2 m
(d) 2.5 m

C. Subjective Questions

1. Write in brief about landscaping of an industry.
2. Describe some important garden adornments.
3. Write about scope of landscaping.
4. Write in detail about water garden.
5. Write in detail about principles of landscaping.

D. Match the Column A and B

Column A	**Column B**
1. Topiary	**a.** Decorative
2. *Bougainvillea*	**b.** Art of beautifying a piece of land
3.Japanese lanterns	**c.** Series of arches joining together
4. Pergola	**d.** Year around flowering
5. Landscaping	**e.** Art of giving to shape of plant

Session 2: Styles of Gardening

Garden: A garden is a space either indoor or outdoor, where flowers, ornamental plants, herbs, vegetables and fruits are grown for utility and aesthetic purposes for the use and enjoyment. A garden is made up of natural as well as manmade elements. It is a valuable and pleasurable adjunct to places where we worship, live and work, such as temple, house, hotels, offices, factories, etc.

Importance and uses of gardens: Gardens are very important in our life and have various endless uses some of which are summarized below:

- Beautify the surroundings resulting in better working environment.
- Reduce the visual pollution by eliminating ugly sites.
- Ornamental plants in garden not only impart aesthetic importance but also improve the air quality.
- Lower the temperature resulting in cool and soothing environment.
- Attract national and international tourists resulting in employment and revenue generation.
- Cut down soil erosion
- Provide an attractive venue for holding various parties and functions.

- Attract various wildlife animals especially birds and small animals like squirrel, rabbits, etc.
- Ideal places for reading, writing and recreational purposes.
- An excellent platform for conservation and multiplication of various plant species especially endangered ones.

Therefore, gardens provide various benefits and improve our quality of life tremendously.

Gardening: It is defined as activity of growing and maintaining of ornamental plants by amateur or professional gardeners. Besides a garden, these gardeners can also work in other areas and plant the ornamental plants and beautify the area such as parks, offices, hotels, roadside, railway stations, etc.

Landscape gardening: Gardens are created through the harmonious blend of art and science. While forming gardens the location, surrounding environment, available resources, animal and plant life, etc. should be taken into consideration. The involvement of already existing aspects in the garden should be made naturally. The main objective of the garden architect is to further beautify the area by adding different features in a landscape as already discussed in detail above.

Types of garden

The gardens are formed in different ways depending upon the objectives. There are different ideas of garden establishment. According to the methods of garden planning, different types of garden are as given below.

A. Formal garden

In case of formal gardens, every component in the garden is symmetrical and in a geometrical form. In these gardens, everything is done as per specific scale and geometrical measurement. The two opposite sides of a garden along the imaginary axis are mirror image of each other. The best examples of formal garden are Persian, Mughal, Italian and French gardens (Fig 4.7)

Fig 4.7: View of formal garden

a. Mughal gardens

Gardens laid out during the rule of Mughal Emperors in India are known as Mughal gardens. These gardens are of formal type. Terraces, running water, walls and gate, *Baradari*, tombs or mosques and scented flowers are the main features of Mughal gardens. There were eight divisions of a garden which symbolized eight divisions of paradise. Examples of some Mughal style gardens are as follows: Mughal garden at Taj Mahal, Agra Nishat Bagh, Srinagar and Shalimar Garden, Srinagar. (Fig 4.8 to 4.10)

Fig 4.8: Mughal garden at Taj Mahal, Agra

Fig. 4.9: Nishat Bagh, Srinagar

Fig. 4.10: Shalimar Garden, Srinagar

b. French gardens

Symmetry and proportionality have an important place in the French style. The rectangles, squares within broad borders were created to give a pattern. Geometric designs and embroidery patterns were created. These gardens are more formal and artificial. Plants grown in the garden were Peach, Plum, Almond, Olive, Orange, Walnut, Fig, Apricot, Cherry and various ornamental plants. This style of gardening came into existence only due to efforts of Le Notre. (Fig. 4.11)

Fig. 4.11: View of a French garden

c. Italian gardens

The most prominent feature of this style is massive flight of stairs and terraces, generally made up of marble, connecting different parts in the garden. There were rose gardens, fountains, pools, sculptures, water canals, decorative urns, topiary and architecturally beautiful buildings, edges and grove of walnuts. One more characteristic of this style is that it includes statues in the garden. The

main purpose of creating such gardens was to show off their wealth as well as status. (Fig. 4.12)

Fig. 4.12: View of an Italian garden

d. Persian style

It is a formal type of garden originally based on the idea of heaven. There gardens were formed by making the terrace on the hilly slopes. The waterfalls, water streams and fountains and a high surrounding wall are the main characteristics of this style. Water flowing canals (*nahars*) – the concept of Persian paradise, "where cooling water flows" in the garden is supposed to be a peculiar feature of this style.

B. Informal gardens

In case of informal gardens, different components and plants in these gardens are arranged randomly but systematically and more naturally. No hard and fast rules are observed capturing natural scenery. These gardens are formed without disturbing the nature and scaling or geometrical measurements are not followed. The best examples of informal gardens are English and Japanese style.

a. English gardens

During 18th century, William Kent, Lancelot Brown and Sir Humphry Repton redefined English gardens. This garden is not departed by fencing or hedging in between the garden and surrounding area. The main components of the English gardens are lawn, flower beds, rockery, herbaceous borders, water streams, statues, waterfalls, shrubbery, etc. (Fig 4.13)

Fig 4.13: View of an English garden

b. Japanese gardens

They are famous in the world for their unique style, natural and spiritual beauty and calmness. Therefore, calmness and quietness are the essential features of Japanese garden. Japanese people are passionate lovers of nature and therefore, various natural landscape elements of the country, like rivers, lakes, waterfalls, mountains, islands, streams, etc. have been created in the miniature form in the gardens. Hence, Japanese gardens are also called "Nature in miniature".

The prominent features of these gardens were water body, paths, stones and evergreen plants. Simple paths and walks, stepping-stones in the water streams, waterfalls, bridges, carved stones, large lakes, islands, avenue trees, etc. are the main components of these gardens. The masonry work in these gardens is comparatively less. The bonsai plants are also placed in these gardens very typically. Other features of Japanese garden are ponds, water basins, stone lanterns, fountains, wells, pagodas, fences and gates and vegetation. (Fig. 4.14)

Fig. 4.14: View of Japanese Garden

Although Japanese gardens have been influenced through different religions, cultures and likings of rulers of different eras, their beauty and uniqueness in gardening style is unparalleled and still admired all over the world by garden lovers. Japanese gardens are divided under the following main historical periods:

Japanese gardens are further classified based on positions, shape and purpose.

Important types are:

a) Hill garden

b) Flat garden

c) Tea garden

d) Passage garden

e) Sand garden.

i. Hill garden: This garden is composed of one or more hills created in the garden with exposed weathered stones and earth mounds. The main feature of this garden is island. The other components included are statues, flat stones, arching stones, ponds, water streams and waterfalls, bridges, different plants, trees, etc. (Fig. 4.15)

ii. Flat garden

These gardens are informally laid out on flat and grassy ground without hills or ponds. The garden is given a flat look of the various natural and manmade elements. To avoid vertical look of the trees, they are trained to lie close to the ground. The various features of the garden are a water basin, stones lying close to the ground, stepping-stones and trees. (Fig. 4.16)

iii. Tea garden

It is an enclosure in a Japanese garden where tea is served to the guests limited to five persons where they sip the tea while standing as there is no sitting arrangement. Such gardens are enclosed by fence preferably of bamboo wood or live bamboo plantations. (Fig. 4.17)

iv. Passage garden

These gardens are laid out in a passage or narrow strip available in between two houses or two buildings. These gardens have limited space with only a few trees, stones and rocks in a proper but informal way as if have grown themselves. (4.18)

v. Sand garden

This garden has no use of plants. Here, vertical and prostrate stones in groups of 2 to 3 are arranged and the gaps between these stones are filled with fine white gravel. This style of garden looks pleasant and effective only when the area is limited. Famous sand garden called Ryoanji garden in Kyoto. (Fig. 4.19)

Different types of Japanese gardens

Fig. 4.15: Hill Garden

Fig. 4.16: Flat Garden

Fig. 4.17: Tea garden

Fig. 4.18: Passage garden

Fig. 4.19: Sand garden

C. Free type of gardening: It is also known as modern/picturesque/artistic type of gardening in which best features of both formal and informal types are combined together for aesthetic purposes in a garden.

Activities

Activity 1: Visit the nearby garden and note down the features and types of the plants.

Materials Required: Herbarium file, pencil, note book, eraser etc.

Procedure:

- Make a visit to the garden area and observe types of the garden.
- Note down the various components of the garden.
- Note down types of the plants which are grown in garden.
- Collect sample of the plant for herbarium

Prepare herbarium and write name and nature of plants.

Check Your Progress

A. Fill in the Blanks

1. Persian garden is made on the idea of .....
2. Mughal garden comes under the ..... type of garden.
3. Hill garden is a type of .....garden.

4. Japanese gardens are also called .....

B. Multiple Choice Questions

1. Shalimar Garden is located at

(a) Lahore
(b) Agra
(c) Srinagar
(d) Delhi

2. In which type of garden different components and plants are arranged randomly but systematically and more naturally.

(a) Formal garden
(b) Informal garden
(c) Free style garden
(d) Wild type garden

3 Eight divisions of a garden which symbolized eight divisions of paradise feature is found in the garden

(a) Japanese garden
(b) Italian garden
(c) Mughal garden
(d) French garden

4. Famous sand garden called Ryoanji garden is located at

(a) Banglore
(b) New delhi
(c) Kyoto
(d) Rome

C. Subjective Questions

1. What are the features of Mughal gardens?
2. Differentiate between formal and informal garden types.
3. Write in detail about different types of Japanese gardens.

D. Match the Column A and B

Column A	**Column B**
1.Garden between two house	a. Persian garden
2. Island	b. French gardens
3. *Nahar*	c. Passage Garden
4. Le Notre	d. Japanese gardens

Module 5
Identification Of Ornamental Plants

Module Overview

Ornamental plants are essential feature without which no garden can be created. Not only do they beautify our surroundings but also purify the environment. There are a wide range of ornamental plants which can be used for all the situations like open, sunny area or shady area. Cultivation of these ornamentals has also become an advantageous enterprise since they are useful as raw materials for various industries. Export of various ornamental plants like foliage plants, dried ornamentals and cut flowers bring valuable foreign exchange vital for economy of our country. and is a viable alternative for diversification of agriculture since per unit income generated through sale of ornamental plants is much higher than most of the field crops. Identification of various important ornamental plants along with information of their important characteristics is helpful in utilizing such plants in beautification of our surroundings and reduction in environmental and visual pollution.

Learning Outcomes

After completing this module, you will be able to:

- Describe the characteristics of annual plants, including their life cycle, growth habits, and the advantages and challenges of growing them in various climates and conditions.
- Explain the features of perennial plants, their growth patterns, maintenance requirements, and the benefits they offer in terms of garden sustainability and biodiversity.
- Identify the unique properties of cacti, succulents, and bulbous plants, including their adaptations to different environments, care requirements, and their roles in horticulture and landscape design.

Module Structure

- Session 1: Annual Plants
- Session 2: Perennial Plants
- Session 3: Cacti, Succulents and Bulbous Plants

Session 1: Annual Plants

Flowering Annuals

Annuals: Annuals or seasonal can be defined as plants which grow from seed, flower and die within one season or one year i.e., they complete their life cycle within one year. Some annuals complete their life cycle within 3 to 4 months, some require 6 to 8 months while others may take 9 to 12 months. (Table 5.1 and Fig. no. 5.1-5.14)

Importance of Annuals

Annuals provide a beautiful display of colour in the garden and change the outlook of garden with the changing season. Many plants have variable length of flowering, colours, ease of cultivation, variable height and shape and possess good fragrance. Annuals can be grown easily, and they beautify the place within a short span of time. They can be grown in various situations like in flower beds, pots, shady location and in hanging baskets individually or in groups. They can be grown with perennial plants as mixed borders. Many annuals are suitable for covering trellis, fences and old tree stumps.

Classification of annuals

Annuals are classified as follows:

A. Growing season

1. Winter Season annuals: These annuals are tolerant to low temperature. These annuals are sown in nursery in September and transplanted in October and flower in the spring i.e. February and March. There are a number of winter season annuals available in different flower form, size and colours. Some common winter annuals are Antirrhinum, China Aster, Ageratum, Daisy, Brachycome, Ice Plant, Calendula, Cineraria, Dianthus (Pink), Coreopsis, Larkspur, Pansy, Petunia, Phlox, Salvia, Stock, Straw Flower, Sweet Pea, Verbena, etc.

2. Summer season annuals: These annuals can withstand high temperature. These annuals are sown in nursery in the end of February or beginning of March, transplanted in the end of March-April and come into flowering in May-June. Some summer annuals like Zinnia and Balsam continue to flower through the rainy season. Some common summer annuals are Cosmos, Gaillardia, Gomphrena, Kochia, Portulaca, Sunflower, Tithonia, Zinnia, etc.

3. Rainy season annuals: These annuals can withstand heavy rains and high humidity in the atmosphere. These annuals are sown in nursery in June and

transplanted in July. Examples are Balsam, Cock's Comb, Marigold, Amaranthus, Gaillardia, etc.

B. Planting location

1. Annuals for edging of beds and paths: Ageratum, Alyssum, Brachycome, Dianthus, Candytuft, Lobelia, Portulaca, Torenia.

2. Annuals for hanging baskets: Petunia, Phlox, Portulaca, Torenia, Verbena, Nasturtium, Impatiens, Allysum.

3. Annuals for rockery: Ageratum, Alyssum, Brachycome, Phlox, Portulaca, Linum, Nasturtium.

4. Annuals for sunny location: Allyssum, Antirrhinum, Balsam, Brachycome, Candytuft, Coreopsis, Carnation, Dianthus, Delphinium, Phlox, Marigold, Helichrysum, Poppy, Pansy, Zinnia, Amaranthus, etc.

5. Annuals for shady locations: Salvia, Impatiens, Cineraria, Nasturtium, Lupin, etc.

C. Fragrance

1. Fragrant annuals: Dianthus, Sweet Alyssum, Sweet Pea, Sweet Sultan, Phlox.

2. Slightly fragrant annuals: Marigold, Carnation, Phlox.

3. Non-fragrant annuals: Petunia, Balsam, Salvia.

Table 5.1: Description of important annual flowers

Sr. No.	Common name	Botanical Name	Method of Propagation	Colour of flowers	Season
1	2	4	5	6	7
1.	**Floss flower**	*Ageratum conyzoides*	Seeds	White, pink	Rainy, winter
2.	**Hollyhock**	*Althea rosea*	Seeds	White, yellow, scarlet, pink, violet.	Winter
3.	**Amaranthus**	*Amaranthus* sp.	Seeds	Spikes-white, pale green, Redish.	Rainy

4.	**Antirrhinum (snap dragon)**	*Antirrhinum majus*	Seeds	Yellow, pink, red, blue	Winter
5.	**Calendula (pot marigold)**	*Calendula officinalis*	Seeds	White, yellow, purple	Winter
6.	**Cock's comb**	*Celosia argentea*	Seeds	White, pink, red, orange	Rainy
7.	**Spider flower**	*Cleome spinosa*	Seeds	Pink, purple, white	Summer, rainy
8.	**Coreopsis (Tickseed)**	*Coreopsis* sp.	Seeds	Yellow	Winter
9.	**Cosmos**	*Cosmos Bipinnatus*	Seeds	Pink, purple, white	Summer
10.	**Larkspur**	*Delphinium ajacis*	Seeds	White, blue, purple, pink	Winter
11.	**Balsam**	*Impatiens balsamina*	Seeds	Pink, red, violet, blue, white	Rainy
12.	**Poppy**	*Papaver rhoeas*	Seeds	White, blue, maroon, pink	Winter
13.	**Phlox**	*Phlox drummondii*	Seeds	White, pink, violet, purple	Winter
14.	**Salvia (sage)**	*Salvia splendens*	Seeds	Pink, violet, white blue	Rainy, winter
15.	**African marigold**	*Tagetes erecta*	Seeds, cuttings	Yellow, orange	All seasons

16.	**Zinnia**	*Zinnia elegans*	Seeds	White, cream, golden yellow,	Rainy
17.	**China aster**	*Callistephus chinensis*	Seeds	White, pink, violet, red	All seasons
18.	**Gaillardia (Blanket flower)**	*Gaillardia* sp.	Seeds	Yellow, cream, orange, maroon.	Summer, rainy

Fig. 5.1 Pot marigold (*Calendula officinalis*)

Fig. 5.2 Carnation (*Dianthus Caryophyllus*)

Fig. 5.3: Indian pink (*Dianthus chinensis)*

Fig. 5.4: Californian poppy (*Eschscholtzia californica*)

Fig. 5.5: Ice plant

(Mesembryanthemum crystallinum)

Fig. 5.6: Petunia (*Petunia hybrida*)

Fig. 5.7: Phlox (*Phlox drummondii*)

Fig. 5.8: Sweet pea (*Lathyrus odoratus*)

Fig. 5.9 Verbena(*Verbena officinalis*)

Fig. 5.10 Hollyhock (*Alcea*)

Fig. 5.11 Antirrhinum (*Antirrhinum majus*)

Fig. 5.12 Gomphrena (*Gomphrena globosa*)

Fig. 5.13 Zinnia (*Zinnia elegans*)

Fig. 5.14 Larkspur (*Delphinium*)

Growing of annuals

Soils: Annuals thrive best in sandy loam, well drained medium fertile soil which is not acidic in nature. The soil requires good ploughing and harrowing to bring it into a fine tilth.

Site: As per the choice, availability of space and nature of annuals, a suitable site should be selected for the best performance of the annuals.

Layout: Layout for planting annuals can be planned on the basis of the flower colour, height and the location where they are to be planted. They may be planted in monochromatic layout where flowers of only one colour are planted in one bed. At times multi coloured flowering annuals are planted together according to suitable colour combinations eg. Yellow marigolds planted with red salvia and blue larkspurs, etc.

Seasonals are also planted according to the height of plants in a border with the tallest plants (Hollyhock, Helichrysum, etc) at the back, followed by Larkspur, Lupin, Salvia, Vanadium, etc in the middle and smaller annuals like Pansy,

Daisy, Alyssum, Dwarf Antirrhinums, Calendula, French Marigold, etc in the first row.

Seed Sowing/ Nursery raising: Almost all the annuals are multiplied by seeds with exceptions like Ageratum and Portulaca, which are also multiplied by cuttings. Seedlings are raised by sowing seeds in raised nursery beds, trays or in pots.

Soil should be of fine tilth with adequate organic matter. Watering should be done regularly but drainage of excess water must be ensured. Seeds should be sown in lines by dibbling, and proper spacing should be maintained to prevent overcrowding. Depth of sowing depends on the size of the seed where bold seeds are sown at 1-2 cm deep, while small seeds like Petunia, Portulaca etc., are sown on the surface and covered with sand or straw mulch.

Prophylactic fungicidal sprays of mancozeb, carbendazim, etc., to prevent collar rot and damping off should be given at regular intervals. The bold seeds of sweet pea, sunflower, morning glory, nasturtium or those annuals which are difficult to transplant (Californian poppy) are sown directly at places where they are to be grown.

The seeds used for sowing should be treated with fungicides and should be of good quality. Small seeds like petunia may be mixed with sand to get uniform sowing. Immediately after sowing the seeds, watering is done carefully. About 10 per cent more seedlings than actual requirement should be raised.

Pricking: The operation of transferring the young seedlings to another bed, pans or trays for better space, nutrients and light is called pricking. The young seedlings are pricked with the help of a pointed stick at 5-7 cm apart in previously prepared holes along with the compost around the neck and the roots of the seedlings. The soil around the roots and the neck of the plant is pressed firmly. The pricked seedlings are transplanted in permanent places. Pricking eliminates the chances of mortality in transplanting as the roots are not disturbed.

Transplanting: Transplanting is the operation of lifting the seedlings from nursery beds or pots and planting them to the permanent beds already prepared. The time of transplanting the seedlings is one month after sowing and should have developed 3-4 true leaves. A day or two before the actual transplanting operation, water is withheld to harden the seedlings (acclimatization). Transplanting is done on a cool/cloudy day or in the evening. Seedlings on the beds are watered lightly before they are shifted for their safe removal. Seedling roots are dipped in fungicidal solution for a minute or two before they are

transplanted. A small hole is made in the garden beds at the place where the seedling is to be inserted. The seedlings are then planted in these holes. The soil around the roots and the neck of the plant is pressed firmly. The transplanting should be done without making any injury to the root system. Only uniform, healthy and vigorous seedlings are used for planting. Watering is given immediately after transplanting.

Watering: Light watering is needed daily only for about a week after transplanting. Regular watering is necessary for all the annuals. In rainy season, less watering is needed. During hot and dry period, water requirement is twice in a week. Watering is preferably given by water can or hosepipe or sprinkler. Over watering as well as forced water should be avoided since the annuals are of an herbaceous nature with shallow roots.

Manures and fertilizers: At the time of soil preparation, sufficient well rotten FYM @ 5 kg and 10 g each of N, P and K per sq. m should be added into the soil to ensure optimum growth and bumper blooms. During vegetative growth, a mixture of chemical fertilizers and organic manure in the form of weak solution is given once in a fortnight. Foliar sprays of NPK and liquid manures are also beneficial for healthy seasonal.

Staking: Some tall growing, weak, slender annuals require some support which may be provided with the help of bamboo sticks tied with wire or thread. Creepers such as sweet pea, morning glory also need supports. Stakes should be attractive and not ugly and should be painted with green colour.

Pinching and disbudding: Many seedlings of annuals such as aster, marigold and *Dianthus* (pink) need pinching. Aster, cosmos and zinnia develop flower buds at early stages which should be pinched off. This will invigorate the axillary buds and increase the number of flowers.

Disbudding refers to removal of the axillary buds per stem to obtain large terminal flowers like in Marigold.

Plant protection: Flowering annuals sometimes suffer from diseases like wilt, dieback, black spot, etc. and insects like aphids, caterpillars and hoppers. For this, spraying of suitable fungicide and insecticide is essential. The details of insect-pest and disease control have been discussed in Unit 2 “Care and maintenance of garden”.

Activities

Visit the campus area and collect the annual plants, identify them and prepare a herbarium.

Materials Required: Herbarium file, DSLR camera, pen, pencil and annual plants.

Procedure:

- Make a visit to the campus area and observe various types of annual plants growing there.
- Photograph the various types of annual plants present in the campus.
- Collect the plant samples and bring them to the laboratory.
- Make a herbarium file of the plant samples.
- Identify the annual plants samples and label them in the herbarium file mentioning botanical name of the plants along with its use in landscaping.

Check Your Progress

A. Fill in the Blanks

1. Pansy is a .....season annual.
2. Kochia is a .....season annual.
3. The operation of transferring the young seedlings to another bed, pans or trays for better space, nutrients and light is called .....
4. Annuals are transplanted in the month of.....
5. Pinching is done to .....branches.

B. Multiple Choice Questions

1. Summer annuals are sown in nursery in the end of

(a) January
(b) February
(c) March
(d) April

2. Staking is done in

(a) Sweet pea
(b) Pansy
(c) Calendula
(d) All of these

3. Annual which emit fragrance is

(a) Phlox
(b) Calendula
(c) Sweet alyssum
(d) Cock's comb.

4. Annual, which can also be multiplied by cuttings is

(a) Kochia

(b) Gaillardia

(c) Portulaca

(d) None of these

5. Normally annual seeds are sown at a depth of

(a) 0.2 cm
(b) 0.3 cm
(c) 0.5 cm
(d) 1.0 cm

C. Subjective questions

1. Write in brief about annuals and their importance.
2. Write about growing of annuals.
3. Classify annuals according to growing season with suitable examples.

D. Match the Column

Column A	**Column B**
1. Sweet alyssum	a. *Delphinium ajacis*
2. Larkspur	b. Sage
3. Gaillardia	c. *Ageratum conyzoides*
4. Floss flower	d. Fragrant
5. Salvia	e. Blanket flower

Session 2: Perennial Plants

Perennials: These are woody or non-woody plants which grow for more than two years.

Classification of perennials

A. Herbaceous perennials

Herbaceous perennials are those ornamental plants which have soft and succulent stems and bear flowers year after year. Among these many herbaceous perennials are available for cultivation e.g. Carnation, Chrysanthemum, Dahlia, Gerbera etc. These generally flower during the winter season and need protection from the hot sun and the desiccating winds in summer.

Importance

1. They are permanent plants and do not require to be raised again and again every year or every season, as in annuals. Only heading back is required in some cases.
2. Beauty lies in their soft stems and foliage, as well as in flowers.
3. The blooming period is long and during non- flowering period, the foliage also adds to the beauty of the garden.
4. Being comparatively hardier than annuals, are easy to grow and some of them bloom for a considerable part of the year.
5. Can be propagated by different methods i.e. seeds, soft wood cutting, leaf bud cutting, suckers etc. and are rather easy to root and grow fast.
6. Can be grown in rows, beds or in groups and can be grown in various places and corners of the garden providing a better landscape. In home gardens, ornamental herbaceous perennials are very popular.

B. Woody perennials

Shrubs

Shrub: A shrub is a woody or semi woody perennial plant with little or no trunk and forms branches close to the base. This grows up to a height from 50 cm to less than four meters (50 cm to < 4 m). The plant whose basal portion is woody, and the upper shoots are soft is called a sub-shrub. A shrub is generally erect and bushy. (Fig 5.15 to 5.31)

Classification of shrubs based on plant height

- Dwarf: Up to 1 m
- Medium: 1-2.5 m
- Tall: 2.5-4.0 m

Standard shrubs: Any shrubs can be trained as standard shrub. In case of full standard shrub, main stem is clean up to 100 cm whereas, in case of half standard shrub, stem is clean up to 50 cm.

Shrubbery border: Area of the garden devoted exclusively for growing shrubs planted in a row or rectangular fashion is known as a shrubbery border.

Utility and importance of shrubs

and beauty. Even in small gardens where planting of trees is not possible, some selected shrubs can find a place.

Shrubs are important because

1. they are available in various sizes, shapes and forms.
2. They bear flowers in different colours and shapes throughout the year.
3. Most importantly shrubs are perennial in habit and need little care.
4. Shrubs are quick growing and flower within a year after planting.
5. Certain shrubs provide colourful foliage, some provide flowers with or without fragrance and some provide both the foliage and flowers.

Selection of shrubs

Selection of a shrub for a particular locality will depend on several factors which are as follows:

1. Availability of space, sunlight, humidity and temperature.
2. Height of the shrub.
3. Type of the shrub - whether flowering, foliage, evergreen or deciduous.
4. Colour of flower, fragrance.
5. Personal choice.

Propagation

Most of the shrubs are propagated by cuttings, however they are also propagated by seeds, and air layering. Delicate shrubs like camellia and flowering cherries are propagated by budding or grafting.

Planting of shrubs

Shrubs are perennial in habit and remain in the soil for a considerable period. Therefore, it needs thorough preparation of the soil and adequate nutrition which should be replenished every year. For the larger shrubs, pits are made of the size 75 x 75 cm^2 or 50 x 50 cm^2 and filled with good manure mixture. The digging of pits or preparation of beds should be done in advance. Planting of evergreen shrubs should be done during the rains and deciduous shrubs during winter. The spacing depends upon the size and nature of the shrubs. After planting, watering is necessary, and some support should be provided initially for establishment of the shrub.

Irrigation: Shrubs need watering regularly during the initial years of establishment. Watering should be provided as and when required and depends on season and rainfall. Over irrigation and stagnation of water should be avoided.

Training and pruning: These operations are necessary to keep the shrubs in a proper shape and size. Training should be given during early stages of growth by supporting and pruning. The removal of any undesirable, interfering, diseased and dead plant part is termed as pruning. Spring and summer flowering shrubs are pruned after flowering. Deciduous shrubs should be pruned during dormancy after leaf fall. Clean cut should be given and cut end should be pasted with fungicidal solution.

Plant protection: Shrubs are hardy perennials and are not attacked by many pests or diseases. Sometimes, leaf eating caterpillars may occur on shrubs. They can be controlled by spraying of suitable pesticides. Sometimes, diseases like root rot, wilt may occur which can be controlled by drenching the soil with Bordeaux mixture.

Suitable shrubs for gardening

1. Acacia

It is commonly known as fragrant acacia. It is spiny, much branched, spreading shrub bearing tassel like scented yellow flowers in winter season. The shrub forms a good hedge when trimmed. It is easily propagated by seeds and cuttings.

2. Acalypha

Acalyphas are a group of shrubs bearing colourful ornamental leaves. There are various varieties of *Acalypha* as per size, shape and colour of leaves. They are used as hedge and for colours in shrubbery. Regular pruning is required for hedges. In some types; long red, yellow drooping spikes of flowers are of ornamental value. It is a quick growing shrub and propagated by cuttings.

3. Allamanda

It is a quick growing shrub and can be grown as a climber. It bears large golden yellow flowers during summer and rainy seasons. The leaves are thick and dark green. This should be pruned after flowering. It requires sunny place for profuse flowering. It is propagated by air layering and cutting.

4. Aralia

Different types of aralias are commonly known to the gardeners. Aralia is an ornamental foliage shrub. Many species are hardy and can be grown in the open. Some aralia species are suitable for pots, in conservatories and used for indoor gardening. The plants are multiplied by stem cuttings, air layering and rarely from seeds.

5. Bauhinia

It is a hardy quick growing shrub with 2.5-3.0 m height bearing red, white, and yellow coloured flowers. Bauhinia is suitable for home gardens and parks. Orchid trees, pride of the cape, bell bauhinia are some of the species of bauhinia. This shrub is easily propagated by seeds.

6. Bougainvillea

Bougainvillea is a most popular ornamental shrub also grown as a climber. It is quick growing and hardy shrub. The colours of the bracts are white, yellow, orange, pink, purple, scarlet and red. In some cultivars, bracts of two colours are found in the same plant. It is generally grown in the ground but can also be cultivated in pots. Bougainvillea is propagated by cuttings or by air layering.

7. Buddleia

It is commonly known as the butterfly bush. It is a group of large attractive shrubs with long perfect lanceolate leaves. The under-surface of leaves is silvery. The branches are quadrangular. The flowering is profuse in long dense panicles composed of small flowers. The shrubs need a lot of space. It is propagated by seeds, cuttings and layers.

8. Caesalpinia

Commonly called as Barbados Pride or peacock flower, is a fast-growing upright shrub. It is a bushy shrub with a few scattered prickles growing up to 3 meter and is very common in our gardens. One type bears orange scarlet flower throughout the year, and other yellow flowers in summer and rains. It is good shrub for hedge. This shrub is propagated by seeds.

9. Calliandra

It is a low branching evergreen tropical shrub with handsome bipinnate feathery leaves and powder puff like flowers. Shrub grows up to 2 m height. *Calliandra* is good for shrubbery, individual specimen in lawn or along paths. Some species flower throughout the year. The propagation is by seeds or air layering.

10. Cestrum

Two species are very common in cestrum. One is *C. diurnum*. *C. d*iurnum is quick growing, bushy shrub which bloom white scented flowers during day time in the summer months and continues till the rains. Diurnum is locally known as 'Day blooming jasmine' or '*Din-ka-raja*'. It is propagated by seeds or cuttings.

Another species is *C. nocturnum* which is commonly known as 'Queen of Night' or '*Raat-ki-rani*' or 'Night blooming jasmine'. It is also quick growing bushy shrub grown widely in Indian gardens for its scented flowers. The creamy yellow or greenish yellow small tubular flowers are produced and are highly scented during night. It is a hardy plant and is propagated by cuttings.

11. Clerodendron

There are many species of *Clerodendron*. Some species are grown as climbers. They are 1.5 – 3.0 m in height. Scarlet flowers are produced in clusters during rainy season. Some species are used as hedge plants, shrubbery, rock garden and for topiary. It grows in semi shaded places. Clerodendron is propagated by cuttings and layering.

12. Crossandra

It is a small shrub growing up to 60 cm in height. The colour of the flowers is white, yellow and orange flowering for a long period. It is propagated by seeds or sometimes through cuttings also.

13. Duranta

It is 2.5 - 3.0 m tall woody shrub with axillary spines. Leaves are of bright green colour and attractive. It bears blue flowers in abundance and berries of green colours. It is most suitable for hedge and for topiary and shrubbery purposes. Some species produce white flowers, while some produce blue flowers with yellow variegated leaves. It is easily propagated by cuttings.

14. Eranthemum

It is a group of shrubs which grows in shady and semi-shady places. The shrubs are grown mainly for their colourful foliage. Some species have a silvery white upper leaf surface irregularly suffused with grey and lower surface is green. Some species have yellow leaf lamina and margins with green central portion. Another species bears leaves with upper surface blackish purple and lower surface purplish with dark veins. In some species, the upper surface of leaves is greyish purple and lower is reddish with violet spots. Eranthemum is propagated by cuttings.

15. Euphorbia

It is a succulent shrub with thinner stems and spines. *Euphorbia milii* var. *splendens* grows up to 90 cm with scarlet coloured flowers and is suitable for border and in rock gardens. Euphorbia is propagated by cuttings.

16. Hibiscus

It is a group of flowering shrubs consisting of several species and hybrids. It is the most popular and widely grown shrub in Indian gardens. The colour of the flowers is red, pink, white, yellow and orange. It is propagated by cuttings and air layering.

17. Ixora

It is a popular group of *Ixora* suited for our gardens. The large terminal trusses of flowers appear during the summer and the rains. The colour may be white, yellow, pink, orange, and orange scarlet. It can be pruned after flowering. *Ixora* are propagated by layering or cutting.

18. Lantana

It is 50 cm to 2.0 m tall widely occurring shrub. The flowers are borne in compact heads. They can be grown in the shrubbery, along paths and for hedging or fencing. The colour of the flowers is yellow, saffron, orange, brick red, white and bluish.

19. Mussaenda

It is an erect shrub with slender branches and thrive better in light shade. The flowers are pale orange and the leafy sepals are white. Flowering time is the rainy season. Some species are grown as climber. It is propagated by cuttings or air layering.

20. Nerium (Kaner)

It is a popularly grown shrub with a height of 2.5 to 4.0 m. The leaves are linear lanceolate. The colour of the flowers is white, pink and deep red and cream. The flowers are sweet scented. It is propagated by cuttings or by layering.

21. Poinsettia

It is successful in partial shade and is a rapid growing shrub 3.0 m in height. The flowers are surrounded by large coloured bracteal leaves during the winter. The colour of the bracts is red, white and cream yellow. It is propagated by cuttings.

SHRUBS

Fig. 5.15: Bougainvillea (*Bougainvillea sp.*)

Fig. 5.16: Red powder puff (*Calliandra sp.*)

Fig.5.17: Allamanda (*Allamanda cathartica*)

Fig. 5.18: Night queen (*Cestrum nocturnum*)

Fig. 5.19: Scarlet bush (*Hamelia patens*)

Fig. 5.20: Gurhal (*Hibiscus rosasinensis*)

Fig. 5.21: Raktak (*Ixora* sp.)

Fig. 5.22: Kamini (*Murraya exotica*)

Fig.5.23: Mussaenda (*Mussaenda* sp.)

Fig. 5.24: Oleander (*Nerium oleander*)

Fig.5.25: Coral plant(*Russelia juncea*

Fig. 5.26: Chandani (*Tabernaemontana divaricata*)

Fig. 5.27: *Tecoma* (*Tecoma gaudichaudi*)

Fig. 5.28: Croton (*Codiaeum variegatum*)

Fig. 5.29: Golden juniper (*Juniperus chinensis*)

Fig. 5.30: Thuja (*Thuja orientalis*)

Fig. 5.31: Acalypha

A. Trees: Trees are perennial/large woody plants, which generally range from 5-25 m in height and possess single upright, distinct trunk, with canopy at the top (Fig. no.5.32 to 5.47). Broadly trees are grouped into two groups.

- Flowering trees (Table 5.2)
- Non-flowering/foliage trees (Table 5.3)

Table 5.2: Description of important flowering trees

S. No	Common name	Botanical name	Propaga-tion	Colour of flowers	Flowering season	Height of tree (m)
1.	**Kachnar**	*Bauhinia purpurea*	Seeds	Purple	Sept. to October Feb. to March	7 - 8
2.	**Bottle Brush**	*Callistemon lanceolatus*	Air layering	Light pink and red	March-April,	5 - 6

					Sept. – Nov.	
3.	**Tree Jasmine**	*Millingtonia hortensis*	Root cutting	White	June to November	12 - 18
4.	**Maulsari**	*Mimusops elengi*	Seeds	Light white	June to December	6 - 8
5.	**Gulmohar**	*Delonix regia*	Seeds	Red	April to June	6 - 8
6.	**Pili Gulmohar**	*Peltophorum pterocarpum*	Seeds	Yellow	February to March	8 - 10
7.	**Neeli Gulmohar**	*Jacaranda mimosifolia*	Seeds	Blue	February to May	12 - 15
8.	**Sita Ashok**	*Saraca indica*	Seeds	Pale yellow	February to May	8 - 10
9.	**African Tulip Tree, Fountain Tree**	*Spathodea campanulata*	Seeds	Dark pink	November - December	10 - 12
10.	**Silk Cotton Tree**	*Bombax malabaricum*	Seeds	Dark red	January to March	15 - 18
11.	**Amaltas**	*Cassia fistula*	Seeds	Yellow	February to May	6 - 10
12.	***Coral* Shower Tree**	*Cassia grandis*	Seeds	Pink	March – May	7 - 9
13.	**Java Cassia**	*Cassia javanica*	Seeds	Pink	April- May	8 - 10
14.	***Kassod* Tree**	*Cassia siamea*	Seeds	Yellow	February-May	6 - 8
15.	**Indian Coral Tree**	*Erythrina indica*	Seeds, cuttings	Red	February-May	5 - 6
16.	**Temple Tree/Pagoda Tree**	*Plumeria alba*	Cutting	Yellow, white	February to May, July-September	6 - 8
17.	**Rain tree**	*Albizia saman*	Seeds	Pink	April – May	15 - 17

18.	**Silver Trumpet Tree**	*Tabebia argentia*	Seeds	Dark yellow	March - May	6 - 10
19.	**Silver Oak**	*Grevillea robusta*	Seeds	Golden-Yellow, light pink	March – June	8 - 10
20.	**Yellow Champaka**	*Michelia champaka*	Seeds, Cuttings, air layering	Yellow	April-September	10-12
21.	**Indian Tulip Tree, Paras Pipal**	*Thespesia populnea*	Seeds	Yellow and Red	March - May	8 - 10
22.	**Palash**	*Butea monosperma*	Seeds	Scarlet	March - May	8 - 10
23.	**White Mulberry**	*Morus alba*	Cuttings	White	April – May	10 - 20
24.	**Kadam**	*Anthocephalus kadamba*	Seeds	Violet	August – Sept.	10 - 12
25.	**Bakain**	*Melia azedarach*	Seeds	Lavender	March - May	6 - 8

Table 5.3: Description of important non-flowering/foliage trees

S. No.	Common name	Botanical name	Propagation	Height of tree (m)
1.	**Royal Palm**	*Roystonea regia*	Seeds	10 - 20
2.	**Fish Tail Palm**	*Caryota mitis*	Seeds	10 - 20
3.	***Areca Palm***	*Chrysalidocarpus lutescens*	Seeds	5 - 10
4.	**Diospyros**	*Diospyros whyteana*	Seeds	10 – 12
5.	**Rubber Tree**	*Ficus elastica*	Air layering	15 – 20
6.	**Fern Tree**	*Filicium decipiens*	Fresh seeds	10 – 12

7.	**Australian Flame Tree**	*Sterculia diversifolia*	Seeds	15 – 20
8.	**Bismarck Palm**	*Bismarckia nobilis*	Seeds	10 – 12
9.	**Badminton Ball Tree**	*Parkia biglandulosa*	Seeds	10 – 12
10.	**Ashoka**	*Polyalthia longifolia*	Seeds	20
11.	**Saptparni**	*Alstonia scholaris*	Seeds /cuttings	8-10

Fig.5.32: Silver oak (*Grevillea robusta*)

Fig. 5.33: Indian pine (*Pinus longifolia*)

Fig. 5.34: Christmas tree (*Araucaria sp.*)

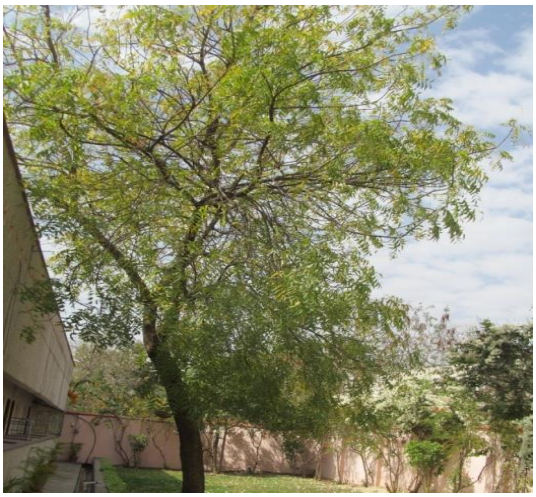


Fig. 5.35: Neem (*Aazadirachta indica*)

Fig.5.36: Amaltas (*Cassia fistula*)

Fig.5.37: Pink Shower (*Cassia javanica*)

Fig.5.38: Bottle Brush *(Callistemon citrinus)*

Fig.5.39: Kachnar (*Bauhinia spp.*)

Fig. 5.40 Siris (*Albizia lebbeck*)

Fig. 5.41 Karanj (*Millettia pinnata*)

Fig. 5.42: Guletura (*Syjulpinia pulchurma*)

Fig. 5.43: Gulmohar (*Delonix regia*)

Fig.5.44: Champa (*Plumeria sp.*)

Fig. 5.45: Fountain tree (*Spathodea campanulata*)

Fig. 5.46 Palas (*Butea monosperma*)

Fig. 5.47 Sita ashok (*Saraka Indica*)

B. Shrubs

Broadly shrubs are grouped into two groups:

- Flowering shrubs (Table 5.4)
- Ornamental foliage shrubs (Table 5.5)

Table 5.4: Description of important flowering shrubs

S. No.	Common name	Botanical name	Method of propagation	Colour of the flowers	Season
1.	**Peacock Flower**	*Caesalpinia pulcherrima*	Seeds, air layering	Yellow, pink	Rainy, summer
2.	**Din ka raja**	*Cestrum diurnum*	Cuttings	White	Throughout year
3.	**Raat ki rani**	*Cestrum nocturnum*	Cuttings	White	Throughout year
4.	**Crossandra**	*Crossandra undulifolia*	Cuttings, seeds	Yellow, white, brick red	Throughout year
5.	**Hawaiian hibiscus**	*Hibiscus rosa-sinensis*	Cuttings	White, Yellow, red, orange	Throughout year
6.	**Ixora**	*Ixora singaporensis*	Air layering, cuttings	Pink, yellow, white, orange	Rainy, summer
7.	**Lantana**	*Lantana camara*	Cuttings	Yellow, orange, white, bricked	Throughout year
8.	**Mussaenda**	*Mussaenda philippica*	Cuttings, layering	Red, yellow	Rainy

9.	**Indian Oleander**	*Nerium indicum*	Cuttings	Pink, white, yellow	Rainy
10.	**Plumbago/ Nila Chitrak**	*Plumbago capensis*	Suckers, layering	Blue	Winter, rainy
11.	**Poinsettia**	*Euphorbia pulcherrima*	Cutting	Red, yellow, pink, white	Winter, rainy
12.	**Egyptian Starcluster**	*Pentas lanceolata*	Cutting	Pink, white	Throughout year
13.	**Bela, Motiya, Mogra**	*Jasminum sambac*	Cutting	White	Rainy, summer
14.	**Kausthi**	*Magnolia pumila*	Layering	Yellow	Rainy
15.	**Chandani**	*Tabernae-montana coronaria*	Cuttings	White	Rainy, winter
16.	**Parijat**	*Nyctanthes arbor-tristis*	Seeds Cutting	White	Rainy
17.	**Firecracker Plant**	*Russelia juncea*	Seeds	Red saffron	Throughout year

Table 5.5: Description of important ornamental foliage shrubs

Sr. No.	Common name	Botanical name	Method of propagation	Shape, size and colour of leaves
1.	**Croton**	*Codiaeum variegatum*	Cutting, layering	Broad coloured, effect growing
2.	**Dracaena**	*Dracaena marginata*	Cutting, suckers	Long green and red leaves, yellow margins

3.	**Pendanus**	*Pendanus sanderiana*	Suckers	Bushy plant, long green serrated margins
4.	**The sword fern**	*Nephrolepis exaltata*	Suckers	Long green leaves
5.	**Ming aralia**	*Polyscias fruti cosa*	stem cuttings	Round variegated leaves
6.	**Euonymus**	*Euonymus radicans*	Seeds and cuttings	Extremely fine in fruits
7.	**Acalypha**	*Acalypha marginata*	Cuttings	Various coloured and shaped leaves
8.	**Aralia**	*Aralia* spp.	Cuttings	Greenish white leaves with succulent stem
9.	**Duranta**	*Duranta plumieri*	Cuttings	Green, golden yellow leaves
10.	**Snow bush**	*Phyllanthus nivosus*	Cuttings, suckers	Leaves mottled with red and pink as well as white.

C. Hedge: Shrubs or small trees planted at regular interval to form a thick continuous screen is called a hedge.

Hedge plants: The plants used for making hedge are called hedge plants e.g. *Tabernaemontana coronaria* (chandani), *Justicia*, *Duranta plumieri* var. *variegata* (Nilkanta/Pigeon berry), etc. These plants provide protection of an area, demark a sector, screen unwanted and ugly sites, act as wind breaks, anti-pollutants and finally beautify the spot (Table 5.6).

Table 5.6: Description of important hedge plants

Sr. No.	Common name	Scientific name	Method of propagation	Colour of foliage
1.	**Forest Jasmine**	*Clerodendrum inerme*	Cutting	Green
2.	**Duranta**	*Duranta plumieri*	Cuttings, seeds	Variegated, green
3.	**Golden Duranta**	*Duranta plumeri var. goldiana*	Cutting, seeds	Yellow
4.	**Dodonaea**	*Dodonaea viscosa*	Seeds	Green
5.	**Peeli Kaner**	*Thevetia peruviana*	Seeds	Green
6.	**Copperleaf**	*Acalypha wilkesiana*	Cutting	Variegated
7.	**Justicia**	*Justicia* spp.	Seeds	Green
8.	**Raat-Ki-Rani**	*Cestrum nocturnum*	Cutting	Green
9.	**Tecoma**	*Tecoma stans*	Seeds	Green
10.	**Lantana**	*Lantana camara*	Cutting	Variegated
11.	**Hawaiian Hibiscus**	*Hibiscus rosa-sinensis*	Cutting	Variegated
12.	**Scarlet Bush**	*Hamelia patens*	Cutting	Green
13.	**Chandni**	*Tabernaemontana coronaria*	Cutting	Green
14.	**Peacock Flower**	*Caesalpinia pulcherrima*	Seeds	Green

D. Edge: They are evergreen, low growing plants having same characteristics as for planting a hedge but are grown to form an edge (Table 5.7).

Table 5.7: Description of important edge plants

Sr. No.	Common name	Scientific name	Method of propagation	Growth habit	Colour of leaves/flower
1.	**Alternanthera**	*Alternanthera amabilis*	Cuttings	Dwarf	Green, red and white
2.	**Pilea**	*Pilea mucosa*	Cuttings	Dwarf	Green
3.	**Justicia**	*Justicia carnia*	Cuttings	Medium	Green, white
4.	**Coleus**	*Coleus* spp.	Cuttings	Medium	Variegated
5.	**Ribbon Plant**	*Chlorophytum comosum*	Suckers	Dwarf	Green-white
6.	**Iresine**	*Iresine herbstii*	Cuttings	Medium	Rich crimson leaves.
7.	**Portulaca**	*Portulaca* spp.	Cuttings	Spreading	White, Yellow
8.	**Geranium**	*Pelargonium hortorum*	Cuttings	Medium	Red White
9.	**Silver Dust Plant**	*Cineraria maritima*	Cuttings	Dwarf	White
10.	**Verbena**	*Verbena* spp.	Cuttings	Spreading	Variegated.

E. Climbers: Those plants which have special structures to climb on support for sunlight and air are defined as climbers (Table 5.8) and Fig. no. 5.48 to 5.51.

Groups of climbers

1 On the basis of climbing habit

a. Twiner: It is a plant which does not possess special structures to climb up the support but climbs by spiraling or coiling. Examples are *Ipomoea purpurea* (Morning glory) and *Lonicera japonica* (Japanese Honeysuckle).

b. Rambler/straggler: It has neither special structure to climb up the support nor does it coil around the support, but it climbs on its own. Examples are

Bauhinia vahlii (*Bauhinia* climber, camel's foot climber), *Quisqualis indica* (Rangoon creeper) and *Hiptage benghalensis* (Madhavi lata/ Hiptage/ helicopter flower).

c. *Straggler*: A *plant* that produces long weak shoots by which it grows over other *plants.* e.g. dog-rose.

d. Creeper: Plants which are too weak to rise vertically above the ground on their own. Produce cluster of roots from the nodes which clasp on support as the shoots grow up. e.g. Morning glory.

e. Trailers: These plants are like creepers but they lack ability to root at their nodes.

2) Foliage climber: A climber having ornamental foliage is called as foliage climber.

3) Flowering climber: A climber having flowers is called as flowering climber.

4) Fragrant climber: A climber having scented flowers is called as fragrant climber.

Table 5.8: Description of important climbers

Sr. No.	Common Name	Scientific Name	Method of Propagation	Remarks
1.	**Asparagus Fern**	*Asparagus plumosus*	Seeds, bulbs	Fragrant
2.	**Trumpet Vine**	*Campsis grandiflora*	Cuttings	Orange flowers
3.	**Monstera**	*Monstera deliciosa*	Cuttings	Shade loving
4.	**Philodendron**	*Philodendron* spp.	Node cuttings	Shade loving
5.	**Money Plant**	*Scindapsus aureus*	Cuttings	Shade loving
6.	**Syngonium**	*Syngonium* spp.	Tip and node cuttings	Shade loving
7.	**Creeping Fig**	*Ficus pumila*	Cuttings	Non flowering

8.	**Golden Shower Trumpet**	*Pyrostegia venusta*	Cuttings	Winter flowering
9.	**Rangoon Creeper**	*Quisqualis indica*	Cuttings	Fragrant
10.	**Flaming Glorybower Vine**	*Clerodendrum splendens*	Cuttings	Red flowering
11.	**Spanish Jasmine**	*Jasminum grandiflorum*	Cuttings, suckers	Fragrant
12.	**Garlic Vine, Wild Garlic**	*Adenocalymma alliaceum*	Cuttings	Garlic odour
13.	***Coral Vine*, Bee Bush**	*Antigonon leptopus*	Cuttings	Pink flower

CLIMBERS

Fig.5.48: Coral vine (*Antigonon leptopus*)

Fig. 5.49: Rangoon creeper (*Quisqualis indica*)

Fig. 5.50: Indian Ivy. (*Ficus repens*)

Fig. 5.51:Flaming trumpet (*Bignoniavenusta)*

INDOOR PLANTS

Indoor (house) plant

A plant which is ornamental for its foliage, flowers or both and satisfactorily adjusts to the indoor environmental conditions (temperature, humidity, light and aeration) of a house is known as indoor plant. These give enchantment in patios, porticos, living rooms, bedrooms, bathrooms, stairs, window sills, walls, roof hangings, and rooftops. These are grown primarily for beautification and secondly for keeping the indoor environment free of pollution. There is a range of evergreen foliage plants such as *Aglaonema, Aloe, Asparagus, Aspidistra, Beaucarnea, Calathea, Chlorophytum, Dieffenbachia, Haworthia, Maranta, Monstera, Peperomia, Pilea, Ruscus, Sansevieria, Scindapsus, etc.* and a range of flowering indoor plants such as *Aeschynanthus, Chrysanthemum, Cyclamen, Haemanthus, Hippeastrum, Huernia, Stapelia*, *Zantedeschia, etc* (Fig. no. 5.52 to 5.62).

Fig. 5.52: *Aglaonema commutatum*

Fig. 5.53: Areca palm (*Dypsis lutescen*)

Fig. 5.54: Dumb canes *(Dieffenbachia*)

Fig. 5.55: *Dracaena* (*Dracaena fragrans*)

Fig. 5.56: Fern

Fig. 5.57: Maranta (*Maranta arundinacea*)

Fig. 5.58: Small-leaf spiderwort *fluminensis*)

Fig. 5.59: Money Plant (Pothos) (*Tradescantia*

Fig. 5.60: Peace lily

Fig. 5.61: Song Of India Plant (Dracaena reflexa)

Fig. 5.62: Spider Plant (Chlorophytum)

Bonsai

The word bonsai (pronounced as bonsigh) is a combination of two Japanese words *bon* meaning 'shallow pan or tray' and *sai* meaning 'planting', *i.e* tray planting. Originally it is a Chinese art where they call it *penzai* or *penzing* which also means 'tray plant' or 'tray scenery'. In Japan they focus it more on the individual tree in pots while in China they focus this art towards landscaping. Plants can be grown in shallow containers with restricted growth. In short, the plants (trees, shrubs and climbers) are maintained in miniature form either singly or in combination with rocks of many forms to show the dignified beauty of an aged tree which has survived the good and bad times of nature for centuries as expressed in the form of its originating the trunk, the bark and branches. The plants most suitable for bonsai are *Acer palmatum, B*amboos, *Butea*, *Callistemon, Ficus* spp., *Ginkgo, Juniperus, Lespedeza, Pinus*, *Prunus,Ulmus, Wistaria, Zelkova, etc* (Fig. 5.63)

Fig. 5.63: Bonsai

Classification of Bonsai According to Height of Main Trunk

1. **Large ones** *i.e.* 4-handed and 6-handed bonsai measuring above 60 cm to 152 cm in height, and also up to 203 cm with 8-handed (Imperial bonsai);

2. **Medium ones** which are quite popular and remain within the limit of 30-60 cm with 2-handed;
3. **Small bonsai** having either two or 1-handed and restricting its height below 30 cm.
4. **Miniature bonsai** whose height restricts to 15-20 cm and these are of four types. These types are very difficult to maintain in their true forms, especially the smallest ones.
    - Poppy seed bonsai 3-5 cm.
    - Fingertip bonsai 5-10 cm.
    - Palm size bonsai 5-15 cm.
    - Mame bonsai 13 to 20 cm.

Making of bonsai

For bonsai making, selection of plant is most important, and then comes the procedure through root pruning, branch cutting, twisting, wiring and tieing to a direction to make these informal or slanting. Generally non-rusting copper wiring is used. After the objectives are attained, the wires are kept for reuse. These are planted in appropriate and suitable containers or pots filled with right quantity of soil mixture. Fertilizer is given bare minimum so that these may not attain luxurious growth but also that these do not die and so is the case for watering. Any extra growth should be removed immediately.

Activities

Visit the campus area and collect various types of plants like trees, shrubs, climbers, edge plants, hedge plants, identify them and prepare a herbarium.

Materials Required: Herbarium file, DSLR camera, pen, pencil and various types of plants.

Procedure:

- Make a visit to the campus area and observe various types of plants growing there.
- Photograph the various types of plants present in the campus.
- Collect the plant samples and bring them to the laboratory.
- Make a herbarium file of the plant samples.
- Classify the plants as trees, shrubs, climbers, edge plants, hedge plants.
- Make separate herbarium file for different types of plants.

Identify the plants samples and label them in the herbarium file mentioning botanical name of the plants along with their various uses in landscaping.

Check Your Progress

A. Fill in the Blanks

1. Plant which lacks special structures to climb up the support but climbs by spiraling or coiling is known as …… ……
2. Common name of *Quisqualis indica* is …… ……
3. Flowering time of hibiscus is……
4. Deciduous shrubs should be pruned during……
5. In case of half standard shrub, stem is clean up to……
6. Woody or non-woody plants which grow for more than two years are called……

B. Multiple Choice Questions

1. Iresine is mostly used as

(a) Edge plant
(b) Hedge plant
(c) Specimen plant
(d) All of these.

2. Japanese honeysuckle is a

(a) Twiner
(b) Rambler
(c) Creeper
(d) Trailer.

3. *Bombax malabaricum* is commonly known as

(a) *Coral* shower tree
(b) Silver oak
(c) Gulmohar
(d) Silk cotton tree.

4. *Asparagus plumosus* can be multiplied by cuttings is/are

(a) Seeds

(b) Bulbs

(c) Both a and b

(d) Cuttings.

5. *Antigonon leptopus produces*

(a) White flowers
(b) Pink flowers
(c) Blue flowers
(d) Yellow flowers

C. Subjective questions

1. Write in brief about herbaceous perennials and their importance.
2. Discuss description of important flowering trees.
3. Write about utility and importance of shrubs.
4. What are hedge plants? Discuss important characters of few hedges plants
5. What are various groups of climbers? Give suitable examples also.

D. Match the Column A and B

Column A	**Column B**
1. Song Of India Plant	a. Honeysuckle
2. Marvel of Peru	b. Acalypha
3. Ornamental foliage	c. Four o'clock flower
4. *Lonicera*	d. *Carissa*
5. Attractive berries	e. *Dracaena reflexa*

Session 3: Cacti, Succulents and Bulbous Plants

Cacti: These are members of the *Cactaceae* family with peculiar shape, size and adapted for desert life. These plants are provided with anatomical, physiological and morphological safeguards to thrive under adverse weather conditions. Leaves are reduced and often modified into spines to conserve moisture and protection and stems are fleshy that store water. Cactus is singular form of cacti (Table 5.9).

Succulents: These are those plants which possess fleshy foliage or stem or both. They store water in their leaves and thrive well in dry climates and do not like more humidity. These plants are suitable for rock garden and sand garden **(**Table 5.10).

Characteristics of cacti

- All members are equipped with areoles or spine cushions.
- They are perennial herbs or shrubs having fleshy stem.
- Fruit of cactus is one-celled berry.
- Flowers are short lived and flower petals arise from the top of the ovary.
- They are mostly leafless.

Characteristics of succulents

- All members inhabit mostly dry desert localities in open situations.
- They are capable of withstanding long hot and dry spells as they store sufficient water in their succulent plant parts.

Difference between cacti and succulents

S. No.	Cacti	Succulents
1.	They have areoles which are minute vertical pores occurring as incomplete canals	They don't have areoles.
2.	They are mostly leafless except one or two genera	They are leafy in nature.
3.	They are less hardy	They are more hardy.
4.	Cacti do not possess great diversity in plant forms	They possess great diversity in plant forms, many have very ornamental appearance while others bear beautiful flowers.
5.	Spines are strictly present	Spines are absent.
6.	All cacti are succulents on account of storing water	All succulents are not cacti.

Table 5.9: Description of important cacti

Sr. No.	Common Name	Botanical Name	Propagation	Ornamental plant part (s)
1.	**Rat Tail Cactus**	*Aporocactus flagelliformis*	Cuttings	Long stem flowers
2.	**Snowball Cactus**	*Mammillaria candida*	Cuttings	Flowers and thorns
3.	**Lemon Ball Cactus**	*Parodia mammulosa*	Cuttings	Yellow flower
4.	**Golden Barrel Cactus/Mother-In-Law's Chair**	*Echinocactus grusonii*	Cuttings	Yellow flowers
5.	**Crab Cactus Or Thanksgiving Cactus**	*Zygocactus truncatus*	Grafting	Scarlet to white flowers
6.	**Orange Cob Cactus**	*Lobivia famatimensis*	Grafting	Pale yellow to red flowers
7.	**Chin Cactus**	*Gymnocalycium multiflorum*	Grafting	Light pink flowers
8.	***Nylon Hedgehog Cactus***	*Echinocereus viridiflorus*	Seeds or cutting	fragrant green to brown flowers
9.	**Apple Cactus**	*Cereus peruvianus*	Seeds	Being drought-tolerant, suitable for xeriscaping
10.	**Scarlet Ball Cactus**	*Parodia haselbergii*	Grafting or *cuttings*	Orange red flowers

Table 5.10: Description of important succulents

Sr. No.	Common name	Botanical name	Propagation	Ornamental plant part (s)
1.	**Aloe**	*Aloe aristata*	Suckers	Succulent leaves
2.	**Florist Kalanchoe**	*Kalanchoe blossfeldiana*	Leaf cuttings	Yellow, red flowers
3.	**Crown Of Thorns**	*Euphorbia milli*	Cuttings	Red, Yellow flowers
4.	**Mauritius Hemp**	*Furcraea gigantea*	Suckers	Leaves
5.	**Agave**	*Agave Americana*	Suckers	Leaves
6.	***Asthisamharaka, Hadjod***	*Cissus quadrangularis*	Cuttings	Green flowers.
7.	**Jade Plant**	*Crassula argentea*	Leaf /stem cuttings	*Succulent* leaf pads, pink, white flowers.
8.	**Devil's Backbone/Slipper Flower**	*Pedilanthus tithymaloides*	Stem cuttings	Dark-green or variegated, fleshy, cordate leaves, red *flowers.*
9.	**Ice Plant/Sedum**	*Sedum spectabile*	Cuttings, divisions	Flowers are white, yellow or rose and red.
10.	**Snake Plant**	*Sansevieria trifasciata*	Division of suckers	Greenish-white emitting fragrance during night.

In Horticulture, bulbous ornamentals include bulbs, corms, tubers, tuberous roots and rhizomes. The stem of these plants is modified into underground food storage structures and they bear attractive flowers and foliage. They have a distinct period of dormancy (Table 5.11).

Table 5.11: Description of important bulbous Plants

Sr. No.	Common Name	Scientific Name	Propagation	Season of flowering	Colour of flowers
1.	**Tuberose**	*Polianthes tuberosa*	Bulbs	Winter, Summer	White
2.	**Belladonna-lily/ March lily**	*Amaryllis belladonna*	Bulbs	Spring, summer	White
3.	**Lilium**	*Lilium* spp.	Bulbs	Summer	Red, variegated
4.	**Tulip**	*Tulipa* spp.	Bulbs	Winter	Variegated
5.	**Dahlia**	*Dahlia variabilis*	Tuberous roots	Winter	Red, yellow, pink
6.	**Glory lily**	*Gloriosa superba*	Tuberous roots	Rainy	Reddish yellow
7.	***Tuberous* begonias**	*Begonia* x *tuberhybrida*	Tubers	Summer	Red, white
8.	**Canna/ Indian shot**	*Canna indica*	Rhizomes	Winter	Red, yellow
9.	**Iris**	*Iris* spp.	Rhizomes	Summer	Violet, White
10.	**Gladiolus**	*Gladiolus hybrida*	Corms	Winter	White, red, yellow, violet
11	**Heliconia/ False bird of paradise**	*Heliconia* spp.	Rhizome	Winter	Red, orange

Activities

Visit the campus area and collect various types of plants like cacti, succulents and bulbous plants, identify them and prepare a herbarium.

Materials Required: Herbarium file, DSLR camera, pen, pencil and various types of plants.

Procedure:

- Make a visit to the campus area and observe various types of plants growing there.
- Photograph the various types of plants present in the campus.
- Collect the plant samples and bring them to the laboratory.
- Make a herbarium file of the plant samples.
- Classify the plants as cacti, succulents and bulbous plants.
- Make separate herbarium file for different types of plants.
- Identify the plants samples and label them in the herbarium file mentioning botanical names of the plants along with their uses in landscaping.

Check Your Progress

A. Fill in the Blanks

1. Succulents are suitable for ..... and .....
2. Dahlia and glory lily are propagated through.....
3. Fruit of cactus is called .....
4. Heliconia is also commonly known as .....
5. Minute vertical pores occurring as incomplete canals in cacti are known as .....

B. Multiple Choice Questions

1. Succulent are possess.....

(a) Fleshy flower
(b) Fleshy fruits
(c)Fleshy roots
(d) Fleshy foliage

2. Tuberose is a

(a) Cacti
(b) Succulent
(c) Bulbous plant
(d) None of these

3. *Crassula argentea* is commonly known as

(a) *Snake plant*
(b) Slipper flower
(c) Sedum
(d) Jade plant

4. Iris can be multiplied by

(a) Corms
(b) Bulbs
(c) Rhizomes
(d) Tuberous roots

5. *Ornamental plant parts of Furcraea gigantea* are

(a) Leaves
(b) Flowers
(c) Fruits
(d) None of these

C. Subjective questions

1. What do you understand by cacti and succulents?
2. Differentiate between cacti and succulents.
3. Discuss description of important cacti and succulents.
4. Discuss description of important bulbous plants.

D. Match the Column A and B

Column A	**Column B**
1. Lilium	a. Mother-in-Law's Chair
2. *Asthisamharaka*	b. Bulbs
3. Golden barrel cactus	c. Rhizome
4. Jade plant	d. Corms
5. Canna	e. *Hadjod*
6. Gladiolus	f. Leaf/stem cuttings

Module 6
Maintain Health and Safety at Work Place

Module Overview

Different work places have different levels of challenges especially in terms of physical hazards inherent in the nature of work or the workplace. Workplace accidents deal a heavy, harmful, unfortunate & counterproductive impact on workers, their co-workers, and their families. They suffer pain, disability, stress and in some cases even loss of employment. Hazard is defined as a dangerous condition or event that portends or has the potential to cause injury, threaten life, damage property, etc. Hazards in agriculture include mechanical hazards, ergonomic hazards, chemical hazards, accidents, hazards related to the occupancy of confined places, occupational diseases and various other hazards arising from associated land, water and air. All efforts are necessary for personal safety of the workers and users of agrochemicals & farm machinery on ethical, health and professional grounds.

Accidents may occur while actually at work in the field, transporting animals and crops, or by falling, slipping, tripping, drowning, machinery hits or even bad/ unhealthy work practices. Hazards caused by human factors, such as those caused by awkward postures and damage to muscles and tendons, mainly due to poorly designed tools, are of common occurrence at agricultural farms.

This Module will help us to learn about various health- & hazard-related problems faced by farm workers and the safe work procedures that ought to be adopted for reducing the lingering risk and preventing the occurrence of accidents.

Learning Outcomes

After completing this module, you will be able to:

- Demonstrate knowledge of the safe handling and application of agrochemicals, including proper storage, mixing, and disposal practices to minimize environmental impact and ensure human health and safety.
- Explain the principles of safe operation and maintenance of agricultural machinery, including identification of hazards, use of personal protective equipment (PPE), and adherence to operational guidelines to prevent accidents and injuries.

Module Structure

- Session 1: Safe Use of Agrochemicals
- Session 2: Safe use of Agricultural Machinery
- Session 1: Safe Use of Agrochemicals

Session 1: Safe Use of Agrochemicals

Chemical hazards in agriculture are related to the dangerous pesticides during use, as well as in maintenance of plant protection equipment's and spraying of pesticides. The term 'pesticides' is indeed a non-specific and broad- based one, and includes as diverse group of chemicals as herbicides, fungicides, insecticides, nematicides, rodenticides, molluscicides, acaricides, plant growth regulators, and chemical fertilizers, commonly used in agriculture.

Harmful effects of agrochemicals

Majority of the pesticides can cause severe to very severe damage to central nervous system, kidney or cause increased risk of cancer. Initial symptoms may be variable and misleading such as muscular weakness, headache, dizziness and nausea. Continuous use of certain agrochemicals, especially pesticides with which our body comes in contact or is exposed, result in long term damage to organs like kidney, liver or the nervous and the endocrinal system inside our body.

Pesticides should not, but often do enter into food products due to following reasons:

- Indiscriminate and extensive use of chemical pesticides
- Non-observance of prescribed safety norms
- Discriminate or indiscrimate sourcing/use of unsafe or sub-standard pesticides
- Wrong advice and supply of pesticides to the farmers by vendors of agrochemicals.
- Leakage or lack of care in disposal of agrochemicals or its waste bye-products by manufacturers.
- Unclean or improper maintenance of the premises of agrochemical storage and preparation area by farmers
- Not using appropriate apparels necessary for personal safety of the field operators and many other factors.

a. Safety procedures in pesticide usage

Individuals who handle and use pesticides should review safety procedures on a regular basis. These are generally exhibited on pesticide container labels or in the literature provided with the market product.

Some important Do's and Don'ts:

- Read and follow label information and directions carefully
- While working with hazardous products, do wear clean personal protective equipment
- Do remove contact lenses before handling pesticides
- Do wash hands after you have handled or have had a contact with a pesticide especially & more so, before eating, drinking, smoking, or using the toilet after handling pesticide
- Do remove and wash off contaminated clothing and any spilled pesticide on an affected person.
- Do Shower and wash the hair and clean under-fingernails at the end of each day.
- Do take proper care in respect of pesticide as per toxicity labels marked on the pesticide packing.

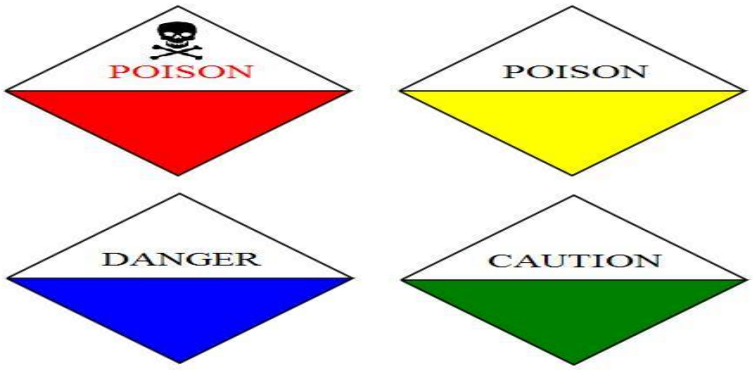


Fig.6.1: Labels of Colours showing toxicity of pesticide

b. Selecting and buying right Pesticides and in required quantity

Safety begins with choosing and buying a pesticide as per need only.

Carry out following check before buying a pesticide:

- Label shows the pesticide as approved for the intended use
- Pesticide can be used in an integrated pest management programme.

- Purchase just as much as is needed by carefully calculating on the basis of cropped or storage area to be covered.
- Read and follow the instructions that come with the agrochemicals.

c. Properly protecting oneself while using equipments

Several articles of personal dressing or covering are essential while using hazardous chemicals or working with powered machines, viz., rubber gloves, respiratory guards/filters, full overalls but not loose fitting (missing buttons/zips), etc.

Fig.6.2: Safety apparel for preparing spray solutions

d. Safety protocol for mixing or applying a pesticide

- Pesticides should be mixed and used at prescribed/recommended rates.
- Use pesticides under favourable weather conditions only; avoid bad weather.
- Don't use muddy unclean water for mixing with pesticide and for personal clean up.
- Whenever handling pesticides, clean water tanks should be nearby.
- Never smoke or eat in between or while mixing or applying pesticides.
- Some pesticide products are flammable. Take care against fire breaking out due to smoking or other use of matchsticks or fireplace.
- Read and follow the instructions on the user guide/label properly
- Use correct pesticide for the pest/disease for which it is meant

e. Use the recommended dose and quantity only

* For preparing the aqueous solution of the pesticide, use outdoor open space

- Use the recommended amounts and recommended dilutions strictly.
- Do not prepare larger amounts than are necessary for field application on a given day only; never try to store for possible future use.

f. During application of pesticides:

- Don't undertake pesticide spraying on a windy day.
- Position yourself in a way that the wind drift blows pesticide spray (or dust) away from your face.
- Before indoor spraying, close the doors and windows of hall/home.
- During the spray operation, keep the nozzle close to the target plants to avoid waste of solution by drift
- Spraying excess quantities will be wasteful and leave residual harmful amounts on the produce, which if consumed will be detrimental to the health of the consumer

While preparing spray solution of pesticide, try to stay away from an open well used to draw drinking water

Fig.6.3: Caution signage's while pesticide spraying

Figure 6.4: Signage for pesticide applied at field

Cleaning and disposal of empty pesticide containers

Pesticide containers should be cleaned when emptied, removing pesticide residues before they dry. When emptying a pesticide container:

- For liquids, transfer the pesticide into a spray tank or mixing tank. Let the last drop get emptied. Use a strong nozzle to triple rinse or pressure rinse metal, plastic, or glass containers, unless otherwise instructed on the label.
- Likewise, for solids, gently shake the bag into tank or hopper until no loose foggy dust is visible. Gently single rinse bags if possible, unless otherwise instructed on the label.

Pesticide Disposal

Disposal of Concentrated Pesticide

Planning your pesticide purchases will minimize excess pesticide concentrates left over after an application or use season. Review records of prior applications. Use the pesticide that is on hand before buying more. Contact the pesticide manufacturer or a local vendor to be sure that old stocks are still effective.

It is best to prepare just the right quantity of pesticide concentrate or solution to avoid disposal problems. It is safer to prepare less quantity than to prepare excess which may have to be disposed of unsafely.

Unopened containers may sometimes be returned to the manufacturer or local dealer. Applicators can also contact the pesticide regulatory body for advice on proper disposal of unused pesticides. If excess quantities are left in storage, either use yourself or let a neighboring farmer use it, if possible.

- Don't stockpile –buy and use as per need.

  If you must have to store pesticides, keep high enough out of reach of children. Do lock all pesticides in a cabinet in a well-ventilated utility area or farm shed.

Disposal of surplus tank mixture:

'Prevention is better than cure' has to be the guiding principle.

- Accurately measure the area to be treated
- Confirm application rates of agrochemicals
- Calibrate application equipment

Best if mixing tank is emptied by using up all the solution prepared. If there is still something left in tank mix at the end of an application, use it according to label directions on another area that requires the same pesticide.

First aid, treatment and safety equipment

Accidents might happen in spite of all precautions and care. It is essential for the students to know about immediate medical aid for a chemical accident and to learn about the safety devices to prevent them.

Fig.6.5: First Aid Box

Chemical poisoning and first aid measures

Chemical poisoning may result from continuous contact, absorption through skin, inhalation of toxic vapor or swallowing it directly. Common symptoms of pesticide poisoning are headache, nausea, vomiting, tremors, convulsion, and difficulty in respiration. A first-aid kit with necessary antidotes should be available at work site for each type of poisoning. Antidotes are always mentioned on the pesticide containers.

Treatment for simple chemical poisoning

i. **Swallowed poison:** If the poison has been swallowed, induce vomiting immediately. Mustard oil or table salt in a glass of warm water is good for this purpose. Touching the throat internally with finger or any smooth, blunt and hard spatula will also induce vomiting. Vomiting process should be continued till clear liquid starts coming out of the stomach. If the patient goes into convulsions or in unconscious state, vomiting should be induced. If the poison is due to ingestion of mercury compounds, egg white and milk should be given first and then vomiting should be induced. At the end of inducing vomiting, soothing substances like raw egg white (mixed with water), butter or cream milk should be given.

I. **Skin contamination:** Contaminated clothes may at once be removed. Contaminated skin should be washed with soap and water also flushed with plenty of water to reduce the extent of injury.

II. **Eye poisoning:** Eyes of the victim may be flushed with plenty of water, keeping the eye-lids open. A quick decisive action is desirable, as a delay of a few seconds may greatly increase the extent of injury. Refer to an eye specialist immediately.

III. **Inhaled poisons:** The victim of inhaled poison should be immediately exposed to open area with fresh air. Keep the patient quiet as far as possible. Provide a

blanket to avoid chilling. If breathing is stopped, artificial respiration technique through mouth may be used.

Safety and protective devices

Protective and safety devices will minimize chances of a major accident. The protective and safety equipment essentially include a gas mask, hand gloves, shoes, eye shields, head gear, protective clothing, respiratory devices, *etc.*

i. **Gas mask:** It is a device to protect the eyes and respiratory tract from toxic gases, and aerosols. It gives clean air to the operator by removing contamination from ambient air by using a filter or bed of absorbent material.

ii. **Hand gloves:** Always use rubberized waterproof gloves, not ones made of leather, cotton or any fluid-absorbing materials.

Fig.6.6: Hand-gloves and mask for head

iii. **Shoes:** Shoes made of rubber or any synthetic waterproof materials are used instead of leather or canvas shoes.

iv. **Eye shields** -: Must be worn to prevent eye poisoning

v. **Protective clothing:** The skin should be protected by wearing an apron while working with treated crops. Wash clothing before reuse.

Fig.6.7: Protective clothing

Health and safety awareness in the workplace

- Encourage seniors to keep an eye on those working at the workplace.
- Use charts and visuals to demonstrate commitment to health and safety.
- Safe work practices, discouraging unsafe work practices.
- Even at the cost of repetition, do communicate that safety is of prime importance while at work.
- Those new to undertaking spray or pesticide applications, must be supervised or advised to report immediately, any adverse developments concerning health of the operator.
- Respond and act promptly to all health and safety concerns.
- Set example in use of all preventive and protective materials and practices.
- Keep children away from operational area or superwise them personally to ensure they are not close to a working machinery or handling devices and equipment for which they are not trained to use.

Amenities and environment

- Train all workers rotationally in use of first aid equipment and provide first aid kits at easily accessible points.
- Insist on first aid training for all field workers.
- There should be a free access to wash room and toilet facilities with running water or stored clean water.
- There should be free access to potable, clean and cool drinking water.
- As far as possible, take steps to prevent entry of poisonous creatures like scorpions, snakes, leeches, *etc.*
- Don't keep flammable materials in large quantities or in easily approachable/accessible areas prone to fire hazard.

Emergency response

- Train a task force for emergency response action for the workplace (e.g. snakebite, fire, confined space entry, heat stress or chemical spill).
- Keep safety awareness level of workers high at all times.
- Maintain emergency response equipment.

Manual tasks for personal safety

- When and where required, use appropriate restraint systems.
- Take care to avoid crush injuries to hands.
- When and where possible use aids to lift or move down/injured animals.
- Try and minimise risk of slips, trips and falls; provide non-slip flooring.

Activities

Demonstration of safety devices and measures to be followed.

Materials Required: First-aid kit, Gas mask, Protective clothing, Eye shields, Hand gloves, Shoes and pictorial charts.

Procedure:

1. Identify the different types of protective devices used while handling and applying chemicals.
2. Understand their use through pictorial charts.
3. Identify and understand about each item and its uses.
4. Discuss about different types of chemical poisoning. What are the immediate symptoms?
5. Demonstrate the use of different protective devices.
6. Prepare chart showing different protective devices and their use.

Check Your Progress

A. Fill in the Blanks:

1. To induce vomiting _____can be used.
2. On contaminated skin _____ should be done.
3. To protect eyes and respiratory tract from toxic gases _____is used.
4. Hand gloves made up of _____should are used to handle chemicals.
5. For inhaled poisons first aid can be_____.

B. Multiple choice questions:

1. Common symptoms of pesticide poisoning are:

(a) Headache
(b) Vomiting and Nausea
(c) Difficulty in respiration

(d) All of these

2. To prevent hazards at working place following materials should be ensured:

(a) SDS
(b) First aid kits
(c) Protective clothing
(d) All of these

3. Emergency services are comprised of:

(a) Ambulance

(b) Fire brigade

(c) Both a and b

(d) None of these

4. Potentially dangerous creatures around house and office buildings include:

(a) Lizards

(b) Snakes

(c) Spiders and Scorpions

(d) All of these

6. What safety measures are required during application of pesticides to the crop?

(a) Mixing of correct quantity of pesticide and clean water and spray during evening time

(a) Use of any type of nozzle and spray mixture

(b) Spraying of insecticides with flat nozzle against the direction of wind

(c) Spraying at any time during the day

6. What safe pesticide handling practices are required to be followed by the farmers?

(a) Wearing clean personal protective equipment (PPE)

(b) Wash hands with clean water before any activity which involves food intake or use of area around mouth, eyes, nostrils, etc.

(c) If an insecticide or its solution happens to fall on the clothing or body of an individual, give a proper wash to remove the pesticide as completely as possible

(d) All of the above

C. Subjective questions

1. What are the first aid treatment measures for chemical poisoning?
2. What protective devices are meant for protection in agriculture field?
3. Define agro-chemicals?
4. Discuss various types of harmful effects of agro-chemicals?

D. Match the Column A & B

A	B
1. Eye	a. Rubber
2. Shoe	b. shield
3. Protective Clothes	c. Apron

Session 2: Safe use of Agricultural Machinery

Agricultural field operations today are dependent on various agricultural machinery, tools and equipment's. Use of machinery demands great care with all necessary safe guards.

The accidents associated with agricultural machineries are caused due to the following reasons:

- Lack of adequate or proper training to operators
- Poor maintenance of tools and machinery
- Using a machine that is not right or suitable for the task at hand
- Failure in following proper norms of a safe system of work
- Failing to follow safe operating or 'safe stop' procedures
- Missing or defective safety devices or machine guards, thus exposing workers to accidents
- Unsafe methods for clearing blockages on the premises or for making adjustments.

Checking the tools and machinery before use

Before starting to work with a tool or machinery, one should carry out a check to make sure that it is in good working condition and is safe to use. While specific needs would vary with the machine to be used, basic checks must always be adopted/exercised:

Check the operator manual of the machine for pre-operative instructions and follow them as advised

- Particular attention is warranted to items like brakes, wheels, moving parts of machine (if openly visible) and tires of tractors/vehicles.
- Make sure that guards and protective covers are securely positioned so that these would not come out lose or allow catching loose articles or body parts
- Promptly repair or replace defective/damaged parts of machine, if any
- Stopping devices should be functioning correctly, e.g., brakes, emergency stops (electric switches).
- While coupling/engaging/attaching equipment or a part to machines, make sure that the coupling/attachment is properly fit and is of appropriate size/specification & is not lose. Don't use wrong/makeshift coupling devices/pieces.
- Vehicular type machines must have clear rear view mirrors and fit, fine, properly working reversing aids.
- If guards over moving parts of a machine are missing, get them fitted out and properly covered before using the machine

Daily/periodic mandatory inspections for use of machinery

1. Check water, fuel, fan belts, *etc.*
2. Inspect hydraulic lines for kinks, cracks and general wear & tear.
3. Once engine is running, check hand and/or air brakes, this ensures that brakes will hold while loading.
4. Inspect the cracks in the metal which may cause equipment to break or parts may come off unexpectedly.
5. Keep a safe distance from the equipment when loading or unloading.
6. Take care if there are any overhead power lines, particularly during loading and offloading or while lift-removing of produce or materials.
7. Do discuss any unsafe actions that come to notice of supervisors so that preventive measures can be taken.

Safety precautions during harvesting and threshing machinery

Guidelines to avoid accidents & enhance safety while at work:

- Familiarize yourself with safety risks & measures to overcome the same.

- Harvesting and threshing machines are most prone to debilitating accidents, *viz.*, crushing, cutting, seizing of body parts, especially hands, feet, trunk.
- Caution operators accordingly
- During field operations with moving vehicles, machinery with moving parts, handling a moving part of a machine, do ensure to wear tight clothing and head/hair cover to avoid entanglement.
- Never clean, maintain, adjust or clear jams when the machine is on.
- Stay clear of outlets, discharges, and all moving parts of machine.
- If equipment breaks down, don't just improvise, get it repaired.
- Avoid coming close to moving parts of a powered machine
- Don't leave a machine with engine running – never.
- Don't let children come near a machine while at work
- Don't refuel machine with engine running
- Don't let flammable articles or substances (like fuel, straw, *etc.*) close to working area or machine in operation
- Do not oil, grease, or adjust the machine during operation. Wait for engine & moving parts to come to a full stop before doing this. Remember, the feeding area of a thresher is the most dangerous. Do not let your hand or a loose sleeve of shirt enter feeding area of a thresher.
- Totally avoid working a petrol or diesel driven machine in a closed shed or garage. Exhaust fumes are dangerous to your health

Health and safety during Combine harvesting

Following points may be mentioned even at the cost of repetition as most of the steps are common to all the heavy duty machines with moving parts.

- Never attempt to lubricate, clean, adjust, or unplug harvesters when the machine or engine is running
- Do not allow anyone to climb onto the machine while it is in motion
- Keep children at a safe distance from the machine
- Always have a fire-extinguisher at hand on engine-operated equipment
- Ensure that the fuel system has no leaks

- While refueling, stop the engine and do not smoke
- When operating around machinery, wear work clothes that fit snugly.

Protective measures during operating machinery

Use of protective clothing is an extra measure of protection. All workers operating machines must wear protective clothing or personal protective equipment as a protection against accident/hazards. Also make sure that the protective dress is safe and fitting to body (not loose or with loose ends).
Features of Protective dress and equipment:

- Good fit, appropriate and cleaned/well maintained.
- Safe and preventive storage to avoid damage, cuts, insect infestation
- No rough edges
- Overall body and coverage using overalls, aprons, vests, socks, gloves
- Avoid/prevent noise pollution while at work.
- Hard hats are always desirable for head protection
- Make sure protective clothing is available for different parts of the body.
- Kept clean, fully functional, and sanitized.

Activities

Demonstrate general inspections for use of the machinery.

Materials required: Different types of equipment, users guide, pen, and notebook.

Procedure:

- Identify and select the machinery
- Check the different parts of machinery
- Identify the open moving parts or feeding parts which pose hazard
- Check assembling of each part of the equipments
- Demonstrate use of machinery after inspection.

Check Your Progress

A. Fill in the blanks

1. During harvesting ensure that the operators should wear _____ and secure their _____to avoid entanglement.

2. Need to protect not to allow anyone to _____ onto the machine while it is in motion.
3. Operators must wear _____clothing.

B. Multiple Choices Question

1. What is necessary to check machinery before start**?**

   (a) Farm operations
   (b) Fill the fuel
   (c) check the tires
   (d) check the lights

2. What type of care is required to avoid any machinery accident?

   (a) Using a machine that is unsuitable for the task

   (b) Using unsafe methods for operations

   (c)Guards and other safety devices missing or defective

   (d) Using safe operating procedures

3. Which of the following safety precautions are necessary while refueling of tractor or other machinery?

(a) Engine in running condition
(b) Engine in off position
(c) Engine in off and no open flame nearby
(d) All of these

C. Subjective Questions

1. Enlist the general inspections of the machinery before use.
2. Describe the health and safety during combine harvesting.
3. Describe the use of protective clothing during machinery operations.

Answer Keys

Module 1: Nutrition and Irrigation

Session 1: Plant Nutrition

A. Fill in the Blanks

1. Essential nutrients
2. 17
3. Carbon dioxide
4. Micronutrients
5. Carbon, hydrogen, Oxygen
6. Manure

B. Multiple Choice Questions

1-c, 2-c, 3-c, 4-b, 5-b, 6-d

C. Match the Column

1-e, 2-d, 3-b, 4-a, 5-c.

Session 2: Methods of Manures and Fertilizer Application

A. Fill in the Blanks

1. Monsoon
2. Broad casted
3. Top dressing
4. Continuous or discreet

B. Multiple Choice Questions

1-b 2-a, 3-c, 4-a

C. Match the Column-

1-e, 2-c, 3-d, 4-b, 5-a

Session 3: Irrigation

A. Fill in the blanks

1. Irrigation.
2. Flood irrigation
3. Basin irrigation
4. 30-35%

5. Drainage

B. Multiple Choice Questions

1-d, 2-c, 3-a, 4-b,

C. Match the Column

1-c, 2-a, 3-b, 4-d

Module 2: Care and Maintenance of Garden

SESSION 1: General Care and Maintenance of Garden Plants

A. Fill in the Blanks

1. Toxicity
2. Desuckering
3. Topiary
4. Depotting
5. Mulching

B. Multiple Choice Questions

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

C. Match the Column

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

Session 2: Integrated Insect-Pests Management

A. Fill in the Blanks

1. Caterpillar;
2. Borers;
3. Leaf miners;
4. Lepidopteran
5. Predator and friendly;

B. Multiple Choice Questions

1. Liquid
2. Nematode
3. 1914

4. Night

C. Match the Column

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

Session 3: Integrated Disease Management

A. Fill in the Blanks

1. Damping off

2. Wilt

3. Powdery mildew

4. Virus

5. Seed treatment

B. Multiple Choice Questions

1. Biopesticides
2. Integrated Disease Management
3. Insect vector
4. Fungal

C. Match the Column

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

SESSION 4: Weed Management

A. Fill in the Blanks

1. Insect pests and pathogens

2. Monocot

3. Dicot weeds;

4. Biennial;

5. Pre -emergence.

B. Multiple Choice Questions

1. Perennial

2. May-June

3. Annual

4. Bioherbicides

5. Pre-emergence herbicide

C. Match the Column

1. -b

2. d

3. a

4. c

Module 3: Establishment and Maintenance of a Lawn

A. Fill in the Blanks

1. Turfing
2. *Cynodon dactylon*
3. Sandy loam
4. Fairy ring disease
5. Dibling

B. Multiple Choice Questions

1. *Cynodon dactylon*
2. Agrotis
3. *Paspalum notatum*
4. Southern
5. All

C. Match the Column

1-c, 2-e, 3-b, 4-a, 5-d

Module 4: Basic Landscape Designing and Garden Components

Session 1: Landscaping and its Importance

A. Fill in the blanks

1. Rust
2. Botany and ornamental horticulture
3. *Cynodon dactylon*
4. Mobility and liveliness

B. Multiple choice questions

1-c, 2-c, 3-b, 4-a, 5-d

C. Match the Column

1-e, 2-d, 3-a, 4-c, 5-b

Session 2: Styles of Gardening

A. Fill in the Blanks

1. Heaven
2. Formal
3. Japanese
4. Nature in miniature

B. Multiple Choice Questions

1. C
2. B
3. C
4. C

C. Match the Column

1-c, 2-d, 3-a, 4-b

Module 5: Identification of Ornamental Plants

Session 1: Annual Plants

A. Fill in the Blanks

1. Winter
2. Summer
3. Transplanting
4. October to March
5. Increase number

B. Multiple Choice Questions

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

C. Match the Column

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

Session 2: Perennial Plants

A. Fill in the Blanks

1. Twiner
2. Rangoon creeper
3. Throughout year
4. Dormancy
5. 50 cm

6. Perennials.

B. Multiple Choice Questions

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

C. Match the Column

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

Session 3: Cacti, Succulents and Bulbous Plants

A. Fill in the Blanks

1. Rock garden and sand garden
2. Tuberous roots
3. Berry
4. False bird-of-paradise
5. Areoles

B. Multiple Choice Questions

1. d
2. c
3. d
4. c

5. a

C. Match the Column

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

Module-6: Maintain Health & Safety at Work Place

Session 1: Safe Use of Agrochemicals

A. Fill in the Blanks:

1) Table Salt and Mustard Oil
2) Wash with soap
3) Gas Mask
4) Rubber
5) Artificial Respiration

B. Multiple Choice Questions

1.- d, 2.- d, 3.- c, 4.- d, 5.- a, 6.- d

C. Match the Column

1.-b, 2.- a, 3.- c

Session 2: Safe Use of Agricultural Machinary

A.Fill in the Blanks:

1. Tighen clothes
2. Climb
3. Protective

B. Multiple Choices:

1.-c, 2.- d, 3.- d

Glossary

Acclimatization: It is practice of withholding water a day or two before the actual transplanting operation to harden the seedlings.

Annuals: Annuals are those plants which grow from seed, flower and die within one year or one season.

Antagonism: The mechanism of limiting or controlling the growth of micro-organism through another micro-organism is called antagonism.

Aphids: These are clustering creatures which suck the cell sap from young and tender plant parts, especially both sides of tender leaves, shoot tips, buds and flowers.

APTI-The Air pollution tolerance index is the tolerance level of plant species towards air pollution from leaf biochemical parameters such as relative water content of the leaf, Leaf extract pH, total chlorophyll and ascorbic acid.

Arches: Arches are semi-elliptical or rectangular metallic entrances made over cemented pillars or walls and covered *cum* trained with beautiful climbers.

Balance: It is the equalization of visual weight from one area of a landscape composition to the other area.

Bio-control or biological control: When some living organisms (parasites or predators such as birds, rodents) or certain plant products are used to control the pests of a crop, it is called bio-pesticide and the method is known as bio-control or biological control.

Biofertilizers: These are microorganisms which add, conserve and stimulate the plant nutrients in the soil, some fixing atmospheric nitrogen symbiotically and some convert insoluble phosphates to soluble phosphates in the soil.

Bio-herbicides: Living organisms such as fungi, bacteria and insects are used to control weed population. Such herbicides are broadly known as Bio-herbicides.

Bird bath: It is a bowl shaped ornamental container which is filled with ample fresh water and kept at for inviting birds in the garden.

Cacti: These are members of the cactaceae family with peculiar shape, size and adapted for desert life.

Carpet bedding: It is planting of dwarf herbaceous plants in a bed or series of beds according to a set design.

Climbers: Those plants which have special structures to climb on support for sun light and air are defined as climbers.

Creeper: Plants which are too weak to rise vertically above the ground on their own. Produce cluster of roots from the nodes which clasp on support as the shoots grow up.

Depotting: It is the removal of plants from pots for planting in the other pot, soil or bed.

Deshooting: It is removal of all the side shoots (offshoots/offsets) emerging from the base of the plant.

Dibbling method: It is a method of planting well matured rooted/unrooted grass cuttings obtained from a close-cut lawn or nursery for the establishment of a lawn.

Dip method: Here cuttings before planting are dipped in the fungicidal solution for certain period.

Disbudding: It is removal of floral buds when a large flower on a plant is desired.

Disease: Any abnormality occurring in a plant due to pathogen is called a disease.

Drainage: Drainage is the process of removing water from the soil that is in excess of the needs of crop plants.

Drip irrigation: It is drop by drop, slow but continuous watering directly to the root zone of the plant with full economy of water.

Dust: It is a dry formulation of pesticide with inert carrier.

Earthing up: It is the technique in horticulture where soil is piled up around the base of a plant.

Edge plants: The plants used for edge making are called edge plants.

Edge: They are evergreen, low growing plants having same characteristics as for planting a hedge are grown to form an edge.

First aid: Assistance given to any person suffering a sudden illness or injury

Floating plants: These plants don't need hold or grip of soil (anchorage) for their survival.

Floral clocks: This is a huge clock operating by electricity having huge hands for showing the seconds, minutes and hours.

Form: It is a broad term showing two or three-dimensional structure and shape of an object or space.

Galls or hypertrophied structure: These are abnormal plant growths caused due to infestation of insects and mites.

Garden: A garden is a planned space, indoors or outdoors, set for the display, cultivation and enjoyment of plants and other forms of nature.

Gardening: It is the activity of growing of plants and maintaining the garden.

Green manure crops: These are those crops which are knocked down in the field for decomposition just before stage of maturation such as sunnhemp or *dhaincha*.

Hardy annuals: They do not require artificial aid for their growth and flower freely in the open.

Harm - Physical injury or damage to health.

Hazard - A potential source of harm

Hedge plants: The plants used for hedge making are called hedge plants.

Hedge: Shrubs or small trees planted at regular interval to form a thick continuous screen is called a hedge.

Herbaceous perennials: These are those ornamental plants which have soft and succulent stems and bear flowers year after year.

Insects: Insects are the organisms belonging to division *Insecta* of animal kingdom, with three pairs of legs and two pair of wings.

Integrated disease management (IDM): It is the integration of the various methods used for avoiding and controlling the diseases.

Integrated weed management (IWM): It involves the utilization of both preventive and curative measures (exclusion, physical, cultural, chemical and biological methods) in well planned way for weed control.

Irrigation: Replenishing the soil water deficit by applying water to the crop is called irrigation.

Landscape gardening: It is an aesthetic branch of Horticulture which deals with planting of ornamental plants in such a way that it creates a picturesque effect.

Landscape: It is the appearance of that portion of land which the eye can view at once.

Landscaping: Landscaping is the art of beautifying a piece of land using garden designs, methods and plant materials.

Lawn: A lawn can be defined as the green carpet for a landscape.

Legislative method (Quarantine): This is a method of preventing introduction of new insect-pests from the exporting countries.

Macronutrients: Those essential nutrient elements which are required in large quantity by plants.

Marginal Plants: These plants keep their roots in shallow water and aerial parts above the surface.

Mites: These are minute, yellow, rusty-green, red, black or brown spider-like 8-legged creatures.

Modern/picturesque/artistic or free type of gardening: In this type of gardening, best features of both formal and informal types are selected to secure the most picturesque effect.

Mowing: It is the process of cutting down lawn grasses with the help of a mower as grasses in the lawn should not be allowed to grow more than 5-7 cm in height.

Mulching: It is the act of applying a 5-10 cm thick layer of covering material on the ground surface around the growing plants.

Myco (fungi)-herbicide: When fungal spores or fungi are used to control the weeds, this is known as myco (fungi)-herbicide.

Non-selective: These are the herbicides that prove lethal to almost all monocots and dicots that come in their contact.

Nutrients: Nutrients are chemical elements which are absorbed by plants in small or large quantities to transform light energy into chemical energy for the synthesis of organic materials.

Nutrition: The essential nutrients required for normal metabolic Activities in the body of an organism or plant is known as nutrition.

Occupational hazards: Hazards experienced in the working place.

Oxygenators: These are oxygenating plants which maintain hygiene and balance in a pool and therefore vital to any pool.

Perennial weeds: These weeds complete their life cycle in more than two years.

Perennials: These are woody or non-woody plants which grow for more than two years.

Pergola: It is series of arches joined together and covered with shading material or plants.

Pinching (stopping): It is removal of the growing tips of the terminal portion of plants to promote bushy growth for more lateral formation and precocious flowering.

Poison: Substance capable of causing illness or death

Post-emergence herbicides: These are the herbicides which are applied after weeds have emerged.

Potting: Potting refers to planting of seedlings, poly bag plants or any other plant uprooted from soil/growing media in pots containing potting mixture.

Pre-plant herbicides: This is a group of herbicides that is applied before planting the main crop.

Pricking: The operation of transferring the young seedlings to another bed, pan or tray for better space, nutrients and light is called as pricking.

Rambler/straggler: It has neither special structure to climb up the support nor it coils around the support, but it climbs on its own.

Repetition: It is use of an element in a design more than once in order to maintain unity, establishing rhythm and sequence, and pulling whole of the design together.

Scrambler: A *plant* that produces long weak shoots by which it grows over other *plants*.

Selective herbicides: These are the herbicides used against specific group of weeds and do not prove harmful for other crops.

Shrub: A shrub is a woody or semi woody perennial plant with little or no trunk and grows up to a height from 50 cm to less than four meters.

Shrubbery border: Area of the garden devoted exclusively for growing shrubs planted in a row or rectangular fashion is known as a shrubbery border.

Side dressing: It refers to the fertilizer placed beside the rows of a crop (widely spaced) like maize or cotton.

Soil drenching: Application fungicide or nematicide to the soil for the control of soil-borne infection of fungi (wilt, damping off, root rot) or nematodes (root-knot, is known as soil drenching.

Solarization: It is the method of increasing soil temperature through absorption of sunlight, so that it destroys the seeds and other propagules of weeds.

Sprinkler irrigation: It is aerial watering of the crop or field with pressure through revolving sprinkler nozzles by pipes fitted with stand. The nozzles revolve due to pressure of water and spreads water in the form of thin spray.

Staking: It is a practice to support the plants growing straight and saving them from bending or lodging.

Sub-shrub: The plant whose basal portion is woody and the upper shoots are soft is called a sub-shrub.

Succulents: These are those plants which possess fleshy foliage or stem or both.

Topiary: The art of clipping and shearing climbers, shrubs, small trees and herbaceous perennials into various artistic shapes is known as topiary.

Topiary: Topiary is an art of giving informal shape to the plants such as birds, animals, and formal shapes such as square, rectangular, triangular, globular, *etc.*

Trailers: These plants are like creepers but they lack ability to root at their nodes.

Transplanting: Transplanting is the operation of lifting the seedlings from nursery beds or pots and planting them to the permanent place already prepared.

Turf: Turf is a piece of earth of about 5 cm thickness and 30 cm width with grass thickly grown over it.

Turfing: Turfing is a method of using different turfs and placing them in a well-prepared soil like bricks in a wall.

Twiner: It is a plant which does not possess special structures to climb up the support but climbs by spiraling or coiling.

Unity: It is the congruous and harmonious relationship among all the characters (elements) in a design in a simple form so that it may appear picturesque.

Weed: An undesirable plant in the field which is responsible for economic losses to the human is called a weed.

List of Credits

Module 1

Fig: 1.1: Micro-irrigation system Courtesy: https://bit.ly/2MPyenZ
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Fig.2.2: De-potted plant Courtesy: Dr. V.K. Tripathi CSAUT Kanpur
Fig. 2.3: Plant prepare for repotting Courtesy: Dr. V.K. Tripathi CSAUT
Fig. 2.4: Chewing and Cutting Courtesy: https://bit.ly/2ktGhcx
Fig. 2.5: Leaf minor Courtesy: https://bit.ly/2J5xqvL
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Fig.2.7: Verticillium wilt of Courtesy: https://bit.ly/30oJldQ
Fig.2.8: Powdery mildew Courtesy: https://bit.ly/2IQoviD
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Fig.2.11: Rose Mosaic Courtesy: https://bit.ly/2kt9Xqj
Fig.2.12: *Chenopodium album* Courtesy: https://bit.ly/2kiOv7o
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Fig.2.14: *Cyprus* spp. (Motha) Courtesy: https://bit.ly/2s6lhwQ
Fig.2.15: *Commelina benghalensis* Courtesy: https://bit.ly/2KUCosu
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Fig.2.17: *Sorghum halepense* Courtesy: https://bit.ly/2IO0C76

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Courtesy: http://tinyurl.com/y5z9zgzt
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Courtesy: https://tinyurl.com/y3rjtvpb

Module 5

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Courtesy: https://tinyurl.com/y2o6js5t
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Courtesy: Balaji Shreedhar Kulkarni,UHS, Bagalkot, Bengaluru
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Courtesy: https://tinyurl.com/y44x7jd2
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Courtesy: https://tinyurl.com/y59op7et
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Courtesy: https://tinyurl.com/yyz8ao5f
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Courtesy: https://tinyurl.com/y23emufr
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Courtesy: https://tinyurl.com/y667ulud
Fig. 5.18: Night queen (*Cestrum nocturnum*)
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Courtesy: https://tinyurl.com/yxsy2dhk
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Courtesy: https://tinyurl.com/y6jbavlf
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Fig. 5.29: Golden juniper (*Juniperus chinensis*)
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Fig. 5.34: Christmas tree (*Araucaria sp.*)
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Courtesy: https://tinyurl.com/yyeod86f
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Module 6
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Courtesy: https://goo.gl/mzBA2Q