FRN - 121

Nursery Technology

Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

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Unit 1: Nursery Management-I

Unit Structure

1.0 Learning Objectives

After completion of this unit, you will be able to:

- understand the concept and importance of nursery;
- discuss the factors considered for selection of the nursery sites;
- understand the development of nursery sites;
- discuss the size of nursery and seedbed;
- describe sowing, methods and timing of seed sowing;
- outline the concept of shading and watering.

1.1 Introduction

Nursery is a place where planting material, such as seedlings, saplings, trees, shrubs and cuttings are raised, propagated and multiplied under favourable conditions for transplanting in prepared beds. It is a place where plants are grown with the intention of eventual planting out. Nursery produces billions of plants every year and saves considerable time for the raising of the next crop. Plants are nourished at nurseries by providing them ideal growing conditions to ensure germination. Raising a nursery from seeds offers a simple and practical way to nourish tender and young seedlings in a well-managed, small and compact area, resulting in improved seed germination of expensive seeds. Setting up a nursery is a long-term venture, and requires planning and expertise. Nursery comprises nursery beds, paths, irrigation channels, shade house, and mist chambers etc.

1.2 Importance of Nursery

The process of growing a forest artificially usually begins with the raising of plants in the nursery. The nursery industry is literally a plant growing industry. There will be always a demand for quality planting material and, in turn, there will always be a need for reliable and reputed nurseries. A good nursery stock is a pre-requisite for a quality plantation. This can be achieved only if the nursery is properly designed and all nursery operations are conducted cautiously. It is very important to raise seedlings in a nursery for a number of reasons. Some of the most important reasons are given below:

i. In the nursery, it is possible to grow and maintain a large number of plants per unit area.

ii. Due to better care and management in the nursery, small and costly hybrid seeds can be raised successfully.

iii. The germination rate of seeds increases and the vigor of the seedlings improves when seeds are sown in seedbeds.

iv. Seedling management can be done in a better way due to the compact nursery area with minimum care, cost and maintenance.

v. It becomes simple to manipulate the growing conditions for plants.

vi. Vigorous and healthy seedlings can be chosen to ensure better and consistent crop growth in the main field.

vii. It becomes feasible to sow seeds off-season, which ultimately results in fetching higher returns.

viii. Because nursery produced crops are better managed, they require less seed than crops that are sown directly from seed.

ix. Planting seeds in a nursery gives additional time for doing preparatory tillage in the main plot.

x. In nursery, controlling weeds, diseases, and insect pests is easy.

The demand for high quality planting material is steadily increasing due to interest in vegetable gardening, fruit tree cultivation, social forestry, agro-forestry and plantation crops. Plant nurseries are necessary to meet public demand, and all small and marginal farmers, gardeners, and farm home owners have realized the value of nurseries (**Fig.1**). In order to fulfill this demand, there is enough scope for the establishment of small nurseries which will improve the income of needy sections of rural communities.

Fig. 1: Nursery

Source: https://images.app.goo.gl/XW7DdesBzZigm2CZ7

1.3 Pre-requisite factors considered for selection of the nursery site

It is very important to critically consider the following factors, while selecting a suitable nursery site. In addition to the physical conditions of the site, one should also consider the final purpose of the seedlings at the time of site selection. The following points need to be considered when setting up a nursery:

1.3.1 Climate

The sites which are exposed to strong dry winds should be avoided unless windbreaks and shelterbelts are available beforehand. Frost pockets, frost holes or exposed sites should not be chosen for a nursery site. Frost holes are generally common in northern India where cold air accumulates in the valley bottom and depressions.

1.3.2 Topography of land

Flat areas which become waterlogged should not be selected for nursery sites. Level or nearly level areas are desirable as the nurseries are to be irrigated. Preferably the site should be on a gentle slope, so that excessive water can be drained without causing erosion. Steeper slopes raise the cost of production of seedlings.

1.3.3 Aspect

In the plains the beds should have longer sides in the east-west direction and a cooler aspect is better than the one exposed to morning sun in frosty localities. Moreover, in the western Himalayas northern aspect is preferred but towards higher limits of altitudinal zone (beyond 1500 m) of species, southern aspect may be preferred.

1.3.4 Altitude

In the hilly zones, location of the nursery becomes more important due to the fact that some species like fir and spruce when raised at lower altitudes usually fail to grow. Therefore, altitudinal zonation of the species should be kept in mind.

1.3.5 Soil and Soil Fertility

Fertile and well-drained soil with sandy loam to loamy texture, good tilth, and medium to small blocky structure should be preferred. The site should be quite free from stones, pebbles or coarse gravel as their removal is expensive. Organic content of at least 2.5%

and pH level between 5.5 and 7.5 should always be preferred for nursery sites. The best site for raising a nursery in the forest is the clear-felled area that contains thick humus layers.

Light sandy soils have been considered best for raising conifers due to the following advantages:

1. They are easier to work and the cost for ground preparation, seeding, weeding and lifting is less.
2. Seeds can be drilled directly into the soil surface whereas in heavy soil, sand has to be imported for covering seedbeds.
3. They dry up sooner after rains.
4. Better root systems are produced in sandy soils and frost damage is usually less in sandy soils.
5. Just like heavy soils, sandy soils flooded easily.

The only drawback with sandy soil is that they are less fertile and require more water, thus needs more watering and nutrients.

Chemical and physical analysis of soil should also be tested before the selection of the site. The refractory, saline and alkaline soils should be avoided for nurseries as the amendments are either difficult or time consuming. Nursery soil should have a mixture of soil, sand and manure in the proportion of 60-30-10 percent respectively.

Nursery soil management practices often influence seedlings capacity so much that growth rates after planting out may differ drastically, with the capacity to endure drought and adverse site conditions differing even more frequently.

1.3.6 Water Supply

The site needs to have a steady supply of water throughout the year. Alkaline and polluted water should not be used for watering the plants. The site should have perennial water supply of 200 liters per day for every 1.00 lac seedlings.

1.3.7 Drainage

Soil drainage significantly impacts the health of the seedlings. Drainage becomes impeded through the formation of a compacted layer when cultivated too wet. Physical limitations in the soil may give rise to poor plant growth and yield, inspite of the most carefully conceived fertility regime. Sites which need draining out in the beginning should not be selected. However, the problem of waterlogging in vertisols can be reduced by adding quartzitic sand (one part of sand to every three parts of soil) and by in-bed drainage measures.

1.3.8 Transportation

The nursery should be readily accessible all year round in order to facilitate transportation of materials required in the nursery and dispatch of seedlings from there.

1.3.9 Labour

Availability of trained labour is very much essential for maintenance of nursery. Labour oriented and timely operations in the nursery demand labour of experienced nature. Women labourers have been found to be more suitable for performing nursery operations.

At the same time, skilled and experienced foresters in seed technology and nursery management are desirable.

1.3.10 Protection from animals

The nursery area must be protected by enclosures so as to prevent damage to the plants by stray animals.

1.3.11 Market needs

Market plays an important role in the success of nursery business. Various type of inputs like seeds, fertilizers, pesticides, fungicides, plant growth regulators, poly bags, agricultural implements, different type of spare parts and other miscellaneous items required in the nursery must be available in the nearby market. The nursery needs to be close to a city or a place where people can easily purchase the plants. On the other hand, developing a system to explore both local and foreign markets is also necessary for the nursery business to succeed.

Check your progress

1. What do you understand by the term nursery?
2. Briefly explain the importance of the nursery in the field of forestry.
3. List some of the important factors suitable for the development of a nursery site?

1.4 Nursery sites and area

1.4.1 Development of Nursery Site

The following key points must be kept in mind during the establishment and preparation of a plan for a nursery site:

- **i.** Location of buildings.
- **ii.** Layout of water distribution system.
- **iii.** Size of sub divisions of nursery area.
- **iv.** Location of roads and paths, wind breaks.

1.4.2 Site Preparation

The site should be cleared properly by removing all stumps, roots, lops and tops. It is recommended to perform a thorough hoeing or plowing to a depth of 30 cm, particularly in areas where plants will be raised in nursery beds. The soil should be levelled to form an even slope or, if a site is flat, then it should be made slightly domed. As far as possible, removing top soil must be avoided. Drainage channels should be dug immediately to prevent soil erosion. Drains should be dug on both sides of the paths and connected to the main drain. In plains, drain should be adequately sloped and steps should be used in hills to check the flow of water. Beds should be separated by main paths (2-3 m wide) for vehicles. Secondary paths should be 1 m wide for movement of wheel barrows. Paths between nursery beds can be 0.5 m wide for free human movement. Location of irrigation channels must be kept in mind while developing the layout plan of the nursery. In the hills, nursery beds are made after terracing. Every terrace has a minimum of one bed with a path on both sides.

1.4.3 Size of the Nursery

The size of the nursery depends upon:

- **i.** The number of seedlings to be produced.
- **ii.** Age of seedlings or transplants at the time of planting out.
- **iii.** Number of transplanting to be done for a particular species.

iv. Area of plantation to be taken up and spacing used in plantation.

Moreover, even for the production of two different species, the area of the nursery may differ. The shape of the area should be as square as possible. Out of the total area laid out for a nursery, only 50% is set aside for sowing and raising seedlings. And the remaining portion is used for permanent roads, inspection paths, irrigation channels, heaps of organic matter and sand etc. A eucalyptus nursery in one hectare area can easily produce 3.5 to 4.00 lac plants, whereas a teak nursery of 5-hectare area only produces one lac of plants. For Chir, raised in polythene bags and planted out at 3 x 3 m, a nursery of 30 sq m. is sufficient for one hectare of plantation. For poplar transplants, 1 ha area will yield only 20000 plants at a spacing of 60 x 80 cm.

1.4.4 Preparation of Beds

There are different types of beds on the basis of purpose and vertical level, these are Sunken beds, Raised beds, Seedbeds, Seed flats, Transplant Beds, Beds for Normal Sowing of Seeds/Planting of Cuttings and Beds for Polythene Bags. **Seed flats** are used for germinating seeds and can be grounded made up of earthen pots, shallow wooden boxes, plastic trays, or wicker or bamboo baskets of portable size (say 50cm x 30cm x 10cm deep). As the seedlings are to be pricked out in another bed for further growth, the rooting medium in seed flats should allow easy lifting, without root damage. The best medium for this purpose is disinfected quartz sand which is particularly suitable in comparatively cooler regions and for coniferous species. Nursery beds should be laid preferably of the same size. The width of the beds should not be kept more than 1.25 m, as it restricts the free hard working of labourers. The length of the bed is variable but 10-15 m is usually preferred. In the hills, a nursery is raised on the southern and northern aspects, and the beds are best laid out from east to west as it provides protection from both sun and frost. The beds should be along the contour in hill terraces and may have a downward slope to allow slow drainage. In the plains, a bed laid lengthwise in an east-west direction can be easily protected from sun by putting up a sunshade on the southern side of the bed. There should be a path between the beds for moving in between, working, and weeding etc. The best time for making the beds is autumn. The soil of the beds should be dug 30 to 45 cm deep and allowed to weather. Later, the soil should be sieved for the preparation of seedbeds. Proper proportions of sand and fully rotten farmyard manure should be mixed up to enhance the quality of soil, as soil-mix affects the growth of both root and shoot of the plant. To avoid damage from termites 5% aldrex dust at the rate of 75 kg per hectare should be added in the soil.

Housing beds for setting polythene bags should be around 1m in width and are sunk to a minimum depth equal to the length of the containers to be kept in the bed. For example, in Rajasthan, housing beds are 37 cm deep, 7m long and 1.2 m wide. The floor of the housing bed should have a 300-500 gauge polythene sheet to act as a barrier to the seedling roots preventing them from penetrating the earth.

Generally, beds are laid out at level with the general ground level, as they are easily irrigated and drained out. In hot and dry areas, the beds are sunken. **Sunken beds** help in collecting run-off water from adjoining areas and reducing evaporational loss from its sides. An evaporational loss from the sides of potted plants is also reduced when they are nearly packed in beds so that their upper surface is in level with that of the surrounding area. Investigations carried out with different types of nursery beds revealed that sunken cemented beds, as compared to sunken beds, decreased the water requirements of nursery stock by 29.8%. This was because there were proportionally fewer root clippings in the sunken cemented beds (Kaul and Ganguli, 1963).

In higher rainfall areas, beds are laid out 10-15 cm above the ground level *i.e*. raised beds. Such **raised beds** are supported by bamboo, stones or wooden posts or sticks to prevent them crumbling in the dry season. Raised beds are also preferred for sowing to raise pricking material in Eucalyptus nurseries. The surface of the beds should be dressed with sand or leaf mould and it should be perfectly flat.

1.4.5 Size of Beds

Beds of 10 x 1 m or 12 m x 1.20 m size are constructed in the plains. Beds are used for seed germination, polypot storage, and for transplantation of pricked-out seedlings. In the hills, smaller beds of 2 m x 1 m size are generally prepared. Yet depending on the availability of the area, the size of beds can be changed. The width of beds should not exceed more than 1.2 m otherwise weeding of seedlings, especially in the middle part of the bed should become a problem. The beds should be oriented in east-west direction in the plains and should follow contours in the hills. In very cold areas where lifting may be restricted due to frozen ground, orienting beds in a north-south direction will facilitate early thawing by the morning sun, and thereby lifting.

1.5 Seedbeds

The plot where seedbeds are to be prepared must be ploughed and properly levelled. Depending upon the texture of soil, a slope of about 1 to 3% was constructed and less slope was made for sandy soils. The soil in the seedbed is light and if required, sand and soil (1:1) was properly mixed; so that the seedlings can break through when germinate. This will also be helpful when plants are lifted for pricking out. Sometimes, seed beds are also covered to hasten germination. The seed beds should not be filled in completely, so as to avoid the washing away of top soil and seed. The surface of the seedbed should be made firm by sprinkling water and then by using a wooden plank. The sowing of seed in seed beds is done more densely than in normal beds.

1.6 Sowing

Sowing is a process of planting seeds into the soil or putting seeds into the ground. Proper precautions should be followed during this agricultural practice, such as maintaining the right distance and depth and making sure the soil is clean, healthy, and free of fungi, illness, and other pathogens.

1.6.1 Methods of seed sowing

Depending upon germination rate, size of seed and container, seed is sown either in lines, broadcast and dibbled into small pits (**Fig. 2**). Spacing in nursery beds between rows is kept at 10-15 cm and 5-6 cm between plants within row, depending upon the species. Very minute seeds like *Eucalyptus*, *Adina*, *Anthocephalus*, *Casuarina* are mixed with equal quantities of sand at sowing time to facilitate uniform dispersal. Such seeds need to be sown

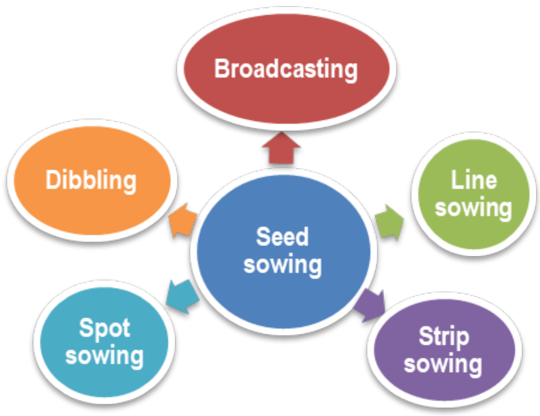

Fig. 2: Methods of seed sowing

on the upper layer of the bed and covered with a fine layer of sand or soil. The seed is watered lightly with a fine rose-can to avoid splashing them out of the soil. Sowing in containers is done after making small holes near the surface. Medium sized seeds of *Acacia*, *Cassia*, *Albizia*, and *Prosopis* should be sown about 1 cm deep. Large sized seeds like *Azadirachta*, *Tamarindus*, *Erythrina* should be sown about 2 cm deep. Very large seeds of *Tectona*, *Ziziphus*, *Swietenia* are sown at 3 cm depth. In general, the sowing depth should be 1 to 2 times of seed diameter. In polythene 1 to 3 seeds are sown depending upon germination capacity of the seed. But after 15-20 days of germination, only one seed should be left per polythene bag. Different methods of sowing are described below:

1.6.1.1 Broadcasting

In this method, seeds are broadcast on nursery beds by hand or mechanically with tractor mounted spinners used in agriculture. Later the beds are covered with sieved compost or farmyard manure. However, this method requires more quantity of seeds and the seeds are not placed at a desired place.

1.6.1.2 Line sowing

Sowing in Lines or drill sowing is done in predetermined intervals in lines or drills conveniently. Seed can be sown by hand or can be drilled with modified agricultural drill. This process reduces the quantities of seed required for seeding. The distance between the lines or drills can be fixed keeping in view the growth rate as well the density of the stocking required. This method of sowing improves the germination and quality of seedlings. In this method, each seed gets independent space, and grows healthy and vigorously. In line sowing, diseased seedlings and weeds can be easily managed.

Hand sowing in drills or lines is still practiced to a large extent. Generally, the trenches are prepared, after filing in the weathered soil, a drill with the help of a peg or hoe is made in which seed sowing is carried out. The sowing may be done in continuous trenches, in interrupted lines or interrupted and staggered lines. Staggered and interrupted line sowing should be followed in undulating and slopy areas. Interrupted line sowing reduces the cost as it is also useful in cleaning the area of weeds. The disadvantage with line sowing is that it takes longer time to fully stocking than compared to broadcast sowing. Line sowing is practiced for raising taungya plantations of Sal in Uttar Pradesh and Bihar.

1.6.1.3 Strip Sowing

In strip sowing seeds are sown in two or more rows or without rows all along the strip. Strips are usually 45-90 cm or even 1.80 m wide. After raking the soil, broadcast sowing is done. Strip sowing bears the advantage over line sowing that chances of failure of any part of the plantation are very rare but it certainly requires more seed and weedings.

1.6.1.4 Spot Sowing

In this method dug up earth is filled back in the trench in a sloping manner, leaving part of the trench unfilled. The balanced soil is used for making a ridge partly out, partly inside the trench. Seed is sown at three intervals starting from the top on the ridge, ground level and a little above the lowest position of the trench. The spots may be rectangular, circular or square, rectangular being preferred for contour sowing. Spot planting is commonly used for establishing conifer plantations in the hilly regions where seedlings are difficult to carry.

1.6.1.5 Dibbling

Dibbing is a common practice for sowing seeds in polythene bags or containers. Dibbling is the process of sowing seeds in shallow holes, made with an iron or wooden hoeing device of at least 10×10×10 cm. Species with large seeds are preferred for dibbling, at least one to two seeds per hole is inserted in the shallow holes. Both the process of seeding and soil working was done simultaneously. Like taungya seeding, stakes are erected nearby for easy location in the subsequent period. It is the cheapest and the quickest method of sowing.

1.6.2 Precautions taken during seed sowing and planting

1.6.2.1 During seed sowing

- **i.** The seeds must be healthy and free from infection.
- **ii.** Small seeds are sown after being mixed with sand for equal distribution.
- **iii.** The seeds must be sown at the right depth.
- **iv.** To prevent crowding, the seeds must be sown at a regular distance, which helps the seedlings to receive sufficient nutrients, water, sunlight and air. In addition, to prevent the seeds or seedlings from drying out or rotting, the soil should not be either too wet nor too dry.

1.6.2.2 During planting

i. Healthy and uniform seedlings must be selected and planted late in the afternoon at recommended spacing, followed by watering.
ii. The seedlings must be treated with fungicides to avoid soil-borne infections.
iii. Transplanting must not be carried out in dry, hot, sunny, windy and humid conditions.

Check your progress

1. What is the size of the nursery site and how is it prepared?
2. Explain different types of beds and their sizes?
3. What do you understand by the term seedbed?
4. What is the difference between broadcasting and line sowing?
5. Explain sowing and different methods of sowing.

1.6.3 Time of Sowing

Sowing time depends upon time to seed ripening, growth rate of species and size of plants for planting out. Spring sowing is practiced for most of the species and the plants are planted out during the rainy season. Seed viability and dormancy are also the important factors that decide the time of sowing. Species with very short seed viability must be sown immediately, otherwise the germination percentage will go down drastically. Seeds with long viability should be sown when temperatures are moderate, *i.e.* between September to October and February to March.

Sowing should be done when soil is sufficiently moist and warm to start germination in the spring or at the onset of rains. Moisture and rainfall are the main critical factors which decide the time of sowing. The soil should be free of frost, as most of the species require high soil temperature for germination. In the snow-fall areas, sowing is generally recommended before the onset of snowfall, as immediately after snow melting conditions becomes favourable for germination, also the seed is protected by snow from birds and other seed-eating animals during winter.

Particularly in low hills, the sowing time varies from September to October during Winter season and from March to April during summers. Similarly, for mid hills, the time of sowing ranges from September to February during winters and from April to May during the summer season. The sowing of seed in the high hill region is done from September to October during winter season and from April to May during the rainy and winter season. The transplantation of healthy seedlings to the seed beds was done in evening hours during summer seasons and in winter season, the transplantation was done during morning hours.

1.7 Quality of Seed

The quality of seed sown at the nursery is considered as an important factor in enhancing production, as seeds are the most basic component of any planting programme. Quality seeds allow for the efficient use of inputs such as irrigation and fertilizer.

Quality seed is

- free from disease and diseased organisms.
- has a high germination index.
- proper moisture content.
- has sufficient weight.

There are different factors that influence the quality of seeds, the main factors are genetic and physical or environmental characteristics. Genetic factors include genetic make-up, seed size and bulk density. Temperature, nutrients and other environmental factors affect seed development.

1.8 Shading

Seedbeds of minute seeds and young seedlings of shade-bearing species require shade in the initial stage. Newly planted saplings need to be guarded from severe weather. Shade can be provided by using shade-nets or polythene sheets. Transplants also require shade, otherwise young seedlings desiccate and perish in the sun. Shade can be provided by trees, thatch, mat, plastic or tin sheet or by a shade house made of net. Shading to the seedbeds is done to achieve the following objectives:

i. To protect young seedlings of shade-bearing species against sun.

ii. To protect seedlings of frost-tender species against frost. The covering should be removed after the soil temperature rises up in the morning and covered again in the evening.

iii. To protect against hail storms or heavy rains during which the young seedlings are damaged due to splash action.

After shading the plants should be hardened-off before planting out in the field. This can be done by gradually decreasing the period of shade and increasing the shadeless period. Shading should be removed during cloudy days and early in the rains. At the end of August, no shade is necessary for most species. Shade should be gradually thinned and removed at least two weeks before planting out along with reduction in watering regime to toughen the plants.

1.9 Watering

After the establishment of plants, watering must be done as per the requirement of individual plants. Excess watering is as harmful as less watering. For most species, irrigation a day by thoroughly saturating the polythene bag is sufficient. During winter, irrigation in 2-3 days will be sufficient. Evening times are best for irrigation but in large nurseries, irrigation is conducted throughout the day to cover the entire area. Water should not fall on young seedlings with much pressure. When the moisture level decreases, the concentration of soluble salts in plant tissue increases, thus maintaining proper moisture level in growing media is very important. The growing media remains dry out due to the presence of excessive soluble salts. In porous growing media, maintaining proper moisture levels can be challenging and need careful monitoring. Irrigation water should ideally have a pH of 5.5 to 7.5, and salt less than 400 ppm.

Adequate supply of water in all the seasons should be available in the nursery. Small anicuts/dams also ensure water in an otherwise seasonal stream for supply to the nurseries. There are different sources of water that help in irrigation. **Open water sources** require less money and water can be partially redirected to the application site via channels and check dams. **Shallow wells** can be dug for temporary nurseries. Artesian wells are used in the terai region of Uttar Pradesh. Centrifugal pumps operated by electric supply or diesel oil and for lifting water from a deep well or through bores done in the ground water are in common uses. **Flow irrigation** and **overhead irrigation** by automizer, sprinkling system and rose-can are the common methods of irrigation in nurseries. Flow irrigation is used in the dry and arid areas with levelled or sunken beds and particularly suits to light soils with good drainage. However, watering by **automizer** is the best-known method for seed beds and watering by **rose-can** is the common practice in the nurseries. **Sprinkling** is a well-designed system of water mainlines for distributing water to the various sections of the nursery. The sprinkling system consists of underground lined pipes and tubes fitted with small holes over the nursery beds. Nowadays, **drill system** irrigation technique is used to foster maximum economy and water use.

Check your progress

1. Why is shading important for nursery plants?
2. What is the best time of sow seeds in the nursery?
3. Explain different sources of water used in irrigation of nurseries.
4. What are the things used for shading nursery?
5. What are the characteristics of a quality seed?

Summary

This unit describes the importance of nursery and nursery is a place where planting material, such as seedlings, saplings, trees, shrubs and cuttings are raised, propagated and multiplied under favourable conditions for transplanting in prepared beds. Climate, topography of land, aspects, altitude, soil, drainage and irrigation systems are some of the important factors need to be considered when setting up a nursery. The size of the nursery depends upon the number of seedlings to be produced, age of seedlings or transplants at the time of planting out and number of transplanting to be done for a particular species. Sowing is a process of planting seeds into the soil or putting seeds into the ground. Different methods of sowing are broadcasting, line, strip, dibbling and spot sowing. Sowing time depends upon time to seed ripening, growth rate of species and size of plants for planting out. Quality seed is used in nursery that is free from disease and diseased organisms, has a high germination index, proper moisture content and has sufficient weight. Shading to the seedbeds is very important to protect against sun, frost and hail storms and adequate supply of water in all the seasons should be available in the nursery.

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Unit 2: Nursery Management-II

Unit Structure

2.0 Learning Objectives

After completion of this unit, you will be able to:

- understand the concept of nursery management;
- discuss intensity, patterns and types of weeding methods;
- describe the procedure of soil preparation;
- discuss transplanting and its advantages;
- describe plant containers, its size and types;
- understand fertilization, micro-propagation and its importance;
- discuss misting units and greenhouse.

2.1 Introduction

Nursery management can be defined as the actions involved in the successful production, care, and marketing of various planting materials like seeds, seedlings, and cuttings in a specific nursery area. Essential nursery management practices include management of fence, roads, paths, irrigation, drainage channels, tools and equipment, management of water sources and management of temporary and permanent plants grown in the nursery.

2.2 Weeding

Weeding is a cultural operation that involves the removal or cutting or suppressing the undesirable vegetation. It is an important operation which should be carried out timely in the nurseries. After germination of sown seeds, some weeds also come which share space, nutrients and water, consequently suppressing the growth of desired plants. In the initial stages, when weeds are small, weeding can be accomplished by hand, but when the weeds become high, the tap root of the weeds should be pulled out with the help of knives or simply a pointed stick. During weeding, undesirable seedlings should also be pulled out for giving proper escapement to the seedlings. But precautions should be taken that desirable tiny seedlings are not pulled out as well as roots of the seedlings are not damaged. While weeding the upper surface of the nursery bed should also be worked up to reduce evaporation. Weeds are eliminated due to:

- danger of fire hazard build-up steadily
- weeds can shelter harmful insects
- weeds can smother and eventually kill trees by their cumulative weight, shading and by exerting pressure.

Weeding is not performed when the soil is wet, to avoid removal of soil with the roots of weeds and consequent exposure to the roots of desired species. Line sowing of seeds facilitates weeding operation manually as well as mechanically. Efforts should also be taken at the time of sowing that only clean seed free of weeds is sown. Application of undecomposed farm yard manure is the major cause for large infestation of weeds in the nurseries. The pulled-out weeds may be used as mulch. There is however the problem of these mulches, as during decomposition it attract pathogens, which then utilize the soil nitrogen to the detriment of the seedling growth.

2.2.1 Intensity of weed control

This depends on species, site and climate. The main consideration for deciding intensity and duration of weeding among others is the Interaction between the tree crop and weeds. Some species on particular sites become established despite the weed competition, while on other sites density of weed growth is such that in the early stage of a plantation it will suppress and kill some or all of the planted saplings. Therefore, before deciding the frequency of weeding, some general principles of weeding may be taken care of. Timing of weeding should be such that it prevents trees suffering serious setback in growth. Also, what is important is the desirability of controlling weeds before the weed species set seed.

Most crops benefit from a total weeding, species which are intolerant of weed growth necessarily require weeding until the tree crop has taken over or dominated the site. Like tree species are tolerant of weeds therefore, weeding frequency may be applied to the level that will just achieve satisfactory results. For example, all eucalypts need complete weeding for their early growth. Many more weedings are required in wet areas than dry sites. Four or even more weedings are needed in the first year where weeds grow profusely and where there is heavy rainfall throughout the year. Similarly, many weedings are needed on sites where the growing season is short.

2.2.2 Patterns of weeding

Two operations are involved in weeding process *i.e.* **suppression** and **elimination**.

Weed suppression can be carried out by trampling or crushing down the weeds by cutting above the ground level.

Weed elimination requires complete removal by killing of weeds. Weedings may be total or partial, the main partial methods are spot or line weeding.

2.2.2.1 Complete weeding

It requires all vegetation competition to be eliminated around the plants and the areas may be harrowed. It is a costly operation and is not possible on a large scale.

2.2.2.2 Line weeding

This pattern is adopted in the areas thickly infested with weeds. In the hills, this method should be carried out on contours. A strip of one meter wide is hoed along the planting line.

2.2.2.3 Strips and inter-row cultivation

In this pattern cultivation is done in the interrow to avoid weed competition and at the same time to grow food crops as in taungya plantations.

2.2.2.4 Spot ringed

This is the standard method for manual weeding used in India. All plant growth around the center of the plant in a circular ring of 1 to 2 m diameter is hoed around the plants. When the weed growth is heavy and the tree growth is slow, the cost of weeding operations may be very high.

2.2.3 Methods of weeding

Different methods of weeding are manual, mechanical, chemical and biological control (**Fig. 1**).

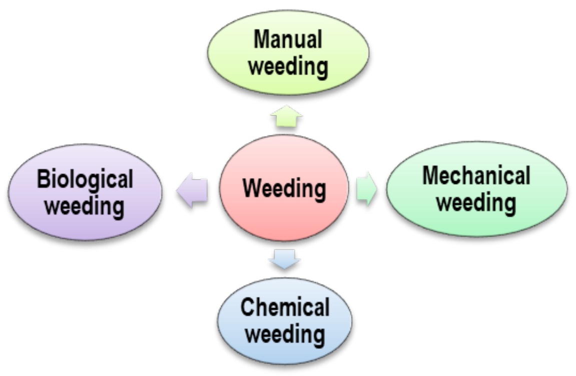

Fig. 1: Methods of weeding

2.2.3.1 Manual weeding

Manual weeding is by far the commonest method. Simple tools such as sickles, brush hooks, shovel, and similar implements are used to cut away the competing vegetation. The operation is usually more effective if some hoeing involving turning over the soil rather than scraping off the weeds is also carried out. Manual weeding needs little skill and supervision and can be carried out on all sites in almost all the weather conditions with all species.

2.2.3.2 Mechanical weeding

In mechanical weeding, a machine operates between the rows of trees, cultivates the ground by harrowing, or shallow ploughing and outs/turns down the weed growth. The machine is pulled by a tractor, so it is workable only when the spacing of rows is at least 3 m. Weeds in the rows are overlooked, but can be removed by supplementing hand weeding near the plants. Mechanical cultivation for weed control has been extensively used in large projects.

2.2.3.3 Chemical weeding

Herbicides are used in chemical weeding and herbicides marketed under different trade names and formulations in the world trade. Precautions should be taken that the recommendation that comes with the chemical is rigorously followed. Only pesticides which are bio-degradable and can be broken down easily in the environment like Organophosphates and carbamates should be used. Inappropriate dosages and techniques should be avoided.

2.2.3.4 Biological weed control

Biological control is still another method in which diseased organism or insect is used which is harmless to the desired plants but kills weed. Use of parasitic plants, selective browsing by livestock and rodents and growing highly competitive replacement plants are other forms of biological control. An excellent example of biological weed control is the prickly pear or *Opuntia* spp.in Australia.

2.3 Soil Working

The soil of the bed should be prepared by dugging at a depth of 30 to 45 cm and then allowed to weather. All types of stones, boulders, roots should be taken out as they obstruct the growth of seedlings. The soil should be sieved through a mesh for the preparation of seed beds. To give a correct texture to the soil, proper proportions of sand

and fully rotten farm yard manure should be mixed up, as composition of soil-mix affects the growth of both root and shoot. Mixed soil having nursery soil and sand in equal proportions proves better than either pure nursery soil, loam or sandy soils to raise plants in the nursery. The soil of most of the nurseries that raise hard wood species requires a blend of loamy and sandy soil. The clayey soils should be avoided as they have poor drainage and aeration thus, they are prone to crack in dry seasons. The moisture content of the soil should be maintained properly to enhance the growth of the plant raised in the nursery.

To avoid damage from termites 5% aldrex dust at the rate of 75 kg per hectare should be added in the soil. In some places, charcoal dust and ashes are mixed up for restoring the correct acidity of the soil. Burning of dry leaves evenly spread in the bed before transplanting to kill harmful insects is also practiced. The residue of burnt leaves also adds nutrients to the soil value of nurseries.

Check your progress

1. Explain nursery management?
2. Differentiate between weed elimination and weed suppression?
3. Briefly explain intensity and methods of weeding.
4. How soil is prepared in a nursery site?

2.4 Transplanting

Transplanting is also called as lining out or pricking out. It is the process of shifting seedling from the seed beds to another part of the nursery or polypots to attain proper size for planting out and to induce compact bushy root system instead of long tap root after giving proper spacing. Pricked out plants are called transplants and those who are not pricked out are called seedlings. Seedlings are lifted from the line sowings or drill sowings or from wild germination as soon as they become large enough to handle safely. Pricking out should be carried out when the cotyledons have dropped or two primary leaves have emerged in addition to cotyledons and the seedling stems have reasonable strength to stand transplanting. The period for attaining such a state of development varies from species to species but it is generally more than three but less than four weeks.

2.4.1 Process of Transplanting

For transplanting the seedlings are first dislodged from the nursery beds. It can be performed by hand pricking by taking out seedlings carefully one by one. In other cases, they are taken out in groups by digging a trench on the side of the width of the seedling bed. The transplanting should be done in a hole longer than the tap root length. The operation should preferably be done on a humid day, during rains or in the evenings.

Transplanting to a large extent is done with the help of a transplanting board. The board consists of a wooden plank 10-15 cm wide. One of its edges has notches spaced at intervals at which the plants are to be transplanted in rows. Furrows in the transplant beds are made beforehand and deep enough, so that the roots of the seedlings settle without folding. The board is placed with its notched edge on the furrow, the seedlings are placed in the notches with their collars slightly above the ground level and tap root suspended in the furrow. The soil is filled back in the furrows; the seedlings get fixed up in the soil. After transplanting, the beds or polypots should be watered with a fine rose, so that the soil settles down in the furrow with full contact with the roots. Transplant beds are fertilized and manured in the same way as the seed beds. Transplanting in some species is done twice where tall plants are required for planting out in the field. Transplanting is a common practice in *Eucalyptus* hybrid, *Pinus roxburghii*, *Fir*, *Spruce*, *Casuarina equisetifolia*, *Cupressus torulosa*, *Acer* spp. etc.

2.4.2 Transplanting of Large Trees

Transplanting large trees has the advantages over sapling planting as less protection is required against cattle and the desired objective is achieved quickly. The trees with good shape and well-developed crown to be replanted are selected. As in large trees the taproot and side roots are well developed and spread over large areas, all the roots cannot be removed with the ball of earth. A trench of a radius of 60 cm to 120 cm away from the main trunk is dug. Normally, radius is double the diameter of the tree, but in any case, should not be more than 120 cm. The trench is 60 cm wide and 90 cm deep, side roots are cut. After digging, the tree is watered so that small roots develop, which bind the earth and the sufficient water is stored in the ball of earth. The tap root is cut only at the time of transplanting. Transplanting during hot weather is avoided.

2.4.3 Advantages of Transplanting

Some of the advantages of transplanting are given below:

- **i.** Plants get sufficient space and nutrients for healthy development.
- **ii.** Crowded plants in the seedling beds lodge and develop long tap roots which do not resist shocking while planting out in the field.
- **iii.** Transplanting helps to attain bushy fibrous root system which is easier to handle and involves less mortality.
- **iv.** Desired size of plants can be obtained in a shorter time. The seedlings can remain in the nursery till they attain proper size for planting.

2.5 Plant Containers

The species which cannot resist the shock of transplanting in the field are raised in plant containers. The custom of planting with root balls for large sized or fragile plants with a difficult strike has existed for a long time. The seedling with a root ball has a totally protected rooting, whereas the rooting system of the ordinary naked root seedling is always more or less injured. Planting with root balls becomes imperative when timbering poor soils becomes a necessity. Container plants have a considerable capacity to withstand a limited dry period following planting, their use therefore can prolong the planting season. Transporting seedlings with root balls presents a problem, in order for the root ball not to dislocate it has to be packed up. From time-to-time potted plants have been raised in the locally available packing material. Some of the containers that are common in use are described below:

2.5.1 Types of Plant Containers

Different types of containers are used in transplanting process (**Fig. 2**). Some of them are described below:

2.5.1.1 Earthern pots

Caked earthern pots with bottoms intact or bottomless bases are used, the latter

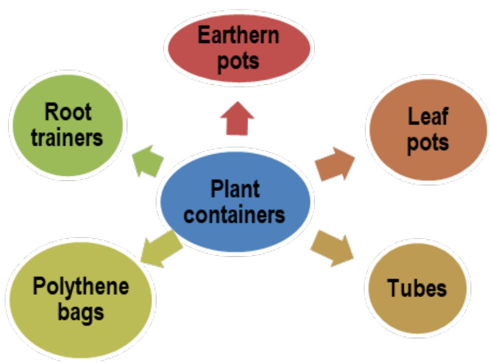

Fig. 2: Types of plant container

can be placed in the pits along with plants, whereas the former has to be broken. Earthern pots are heavy, fragile and expensive. They are rarely used now.

2.5.1.2 Leaf Pots

Various types of leaf cups (called donas in Hindi) are used from time to time for raising a variety of plants in the Indian subcontinent especially in the tribal dominated areas. Leaves of *Shorea robusta*, *Ficus* are used for preparation of donas. In West Bengal, *Sal* seedlings are raised in a specially prepared cylindrical cup which is 20 to 30 cm long and 10 cm in diameter. They are filled with soil and kept under shade on a layer of leaves.

2.5.1.3 Tubes

Bamboo tubes are extensively used for raising a number of species. Bamboo tube can be easily made by cutting the internode into two and tieing it with a fine wire or thread to form a tube. Baskets made of bamboo, mulberry or *Tamarix* sticks are also used for transportation of plants from nursery to the planting site. In order to grow very large seedlings (more than one metre) reinforced (laminated) polythene sacs are being increasingly used. Iron coal tar drums, and concrete pots are also used where the height of the plants is more than 2-2.5 m.

In these cases, the pots or the drums are split into two and are bound with a piece of steel wire before filling with soil. The wire is loosened and the plant with the ball of soil is removed for planting out. Fertilizer bags can also be used for raising larger plants.

2.5.1.4 Polythene bags

To take up massive afforestation in wastelands and for the introduction of exotic plants, the importance of polythene bag plants has increased tremendously. Polythene bags can be prepared conveniently of any size in large quantities. They remain undamaged during use and unused containers can be stored. Polythene bags are cheaper and effective over a wide range of conditions. Their transportation is easier, safer and less expensive as compared to other plant containers. The polythene containers can be transparent or black, the black being more durable. The transparent containers are liable to have algae and moss and the transparent bags reflect the heat, keeping the soil and root zone cooler in hot regions, hence suitable for these areas.

2.5.1.5 Root trainers

Nowadays, root trainers are employed in nurseries. It is a conical-shaped rigid container made up of cells arranged in groups of 16 to 30 and built into a frame of moulded plastic sheet. The bottom opening is known as a drainage hole, and the root trainers are suspended on a wire frame at least 10 cm above the ground. This method prevents root coiling that occurs in polythene bags and growing medium is filled in the root trainer.

2.5.2 Size of the plant containers

The size of the container varies for species to be raised, age and size of the planting stock required as well as climatic conditions of the site. The size of the container has an effect on its weight when filled with soil which is a direct concern for handling and transplanting seedlings. The cost for maintenance in the nursery also rises with its increasing size. The objective should, therefore, be to use the smallest container compatible with the successful establishment and subsequent growth development of plants. The basic principle is that one should not grow a large size seedling in a small container. This can create the problem of root coiling which affects the health of the seedling or kills it. The coiled roots fail to grow down the soil, cut off in root water transport and thus the trees are uprooted in storm or are scorched drought. It is reported that 250 to 350 cm^3 of soil is needed to produce plants of 25 to 35 cm tall. The length of bags cannot be reduced as in seedlings; the root should be at least half the length of shoot.

In other countries, minipots of size 15 cm by 15 cm have been developed and extensively used. The use of containers has occasionally caused root malformation of seedlings and in minipots, chances of malformations are high. When the plants are kept too long in containers the restriction of lateral root growth may cause distortion, coiling and spiraling which may later lead to basal stem snap, reduced wind firmness and stunted growth. These symptoms appear later in the field and sometimes go unnoticed. To reduce root coiling, nursery operations should be so regulated, that the plants do not grow oversized and before outplanting and to mitigate the damage from coiling, it is better to completely remove the container at the time of planting. For raising fuelwood and fodder trees for social forestry projects polythene bags of 100-gauge, 10 cm diameter and 20 cm long are sufficient, whereas fruit trees require polythene bags of 150-gauge, 15 cm diameter and 30 cm long.

2.6 Fertilization

Fertilization is one of the most important aspects of raising high-quality nursery stock. Seedlings rapidly drain the mineral nutrients stored in seeds, whereas cuttings have restricted nutrient reserves. To attain ideal growth rates, nursery plants must rely on nutrition intake from the growing media through their roots. Plants require appropriate mineral nutrients in the proper balance for basic physiological activities like photosynthesis, as well as to stimulate rapid growth and development. Without an adequate supply of mineral nutrients, growth slows and plant vigour decreases. Proper fertilization can increase growth rates by three to five times compared with regular condition. Fertilizers are often sprayed just before or right after planting. The frequency and amount of fertilizer application totally depends on crop, soil and season.

Growth rate of plant and quality of nursery stock is totally dependent on the availability of mineral nutrient. When nutrients are provided in appropriate time, amount and ratio, nursery plants can grow many times faster than in nature. High-quality nursery stock is supplemented with extra nutrients to boost growth after outplanting. Thirteen mineral nutrients are considered important for plant growth and development, and they are classified as macronutrients and micronutrients based on their concentrations in plant tissues.

Plants grown in container receive nutrients from a variety of sources, like growing media, irrigation water, helpful bacteria, and fertilizer. Many container nurseries that cultivate native plants use synthetic growth media like peat moss and vermiculite. Because media are fundamentally barren, nurseries either apply a starter dosage of fertilizer or begin liquid fertigation (irrigation water containing liquid fertilizer) right after germination.

There are numerous types of fertilizers available for use in native plant nurseries, each with a unique source material, nutrient quantity, and nutrient release method. Inorganic and organic fertilizers are the two most commonly used fertilizer in nursery plantations. Inorganic fertilizer includes potassium magnesium sulphate and ammonium nitrate, whereas organic fertilizer includes animal manure, sewage sludge, compost, fish emulsion, and other animal waste. Farmyard manure (FYM) or other bulky manures was evenly spread into the soil and then mixed well by harrowing. Concentrated organic manures must be applied in advance as they require soil bacteria to break them down for plant availability.

Check your progress

1. What is transplanting?
2. Explain different types of plant containers.
3. Write advantages of transplanting.
4. Why fertilization is important in nursery management?
5. Name different types of fertilizers used in nursery plantation.

2.7 Micro-propagation

Micropropagation is the process of producing plants from extremely small plant parts, tissues, or cells that are cultivated aseptically in test tubes or containers under regulated nutritional, environmental, and aseptic conditions. All biological principles of micropropagation techniques are based on the phenomenon known as cell totipotency, which means that a plant cell has the ability to develop into a full-fledged plant containing different organs. Micropropagation differs from other vegetative propagation methods because in micropropagation, extremely little plant part known as explant serve as a starting material, and the explants are kept in small containers with a clearly defined culture media. Furthermore, micropropagation requires highly aseptic environment and produces an enormous quantity of propagating material in a short period of time.

Micropropagation incorporates a variety of culture techniques, including meristem culture, callus culture, shoot bud regeneration, somatic embryogenesis, ovule culture, embryo culture, anther culture, and protoplast culture. Micro propagation is an integrated procedure that involves isolating cells, tissues, or organs from selected plants, surface sterilized and incubating them in a growth-promoting, sterile media and environment to create a large number of plants. Micro-propagation involves four phases, which are:

1. Explant establishment in culture medium
2. Proliferation and multiplication
3. Plant establishment and rooting
4. Acclimatization or hardening

2.7.1 Importance of micro-propagation

Vegetative propagation has long been employed to maintain genetic homogeneity since it provides the quickest option to introduce improved material into production by reproducing the genetic composition of selected individuals. Micropropagation using tissue culture techniques is one of the most recent vegetative propagation strategies. Micro-propagation employing the tissue culture approach offers unique capabilities to rapidly multiply elite trees via organogenesis or somatic embryogenesis. Micropropagation, or the process of producing plants by tissue culture, is widely utilized in *Eucalyptus* plantations.

2.8 Misting units

Misting is a technique for reducing moisture loss in plants by soaking the foliage of rooted cuttings at regular intervals. Misting is effective for rooting leafy cuttings, but is not recommended for succulent plants. Mist beds can be utilized in greenhouses throughout the year or during the growth season for nursery stock. Intermittent misting produces better outcomes than constant misting for most plants. Constant misting consumes water, depletes nutrients from leaves, and drops soil temperature that limits root development. Over-misting is considered less harmful than over-watering. Mist propagation became widely accepted and it reduces leaf transpiration in two ways. Misting intervals should be set to keep all cuttings consistently wet. Small farmers primarily employ mist propagation units, while commercial nurserymen in advanced countries use highly advanced equipment. Misting units provide more than 85% of relative humidity.

2.8.1 Working of misting units

The misting unit can be set up either in glasshouse or in polyethylene tunnel. Usually, it is set up on propagation beds of 1.2 m wide. The optimal pH of water for usage in a misting unit is 5.5 to 6.5. Misting unit has 5 control mechanisms. Timer, electronic leaf, thermostat and timer, screen balance and photoelectric cell. It is important to use nozzles that can produce a very fine mist. A fine mist is sprayed over the cutting at regular intervals throughout the day and night. The mist unit is controlled by a time clock that activates a magnetic solenoid valve. The mist is turned on for 3-5 seconds to wet the leaves and then turned off when they dry. Later, the mist is turned on again.

2.8.2 Use of misting units

Nowadays, misting unit is widely used by nurserymen and other plant propagators throughout the world due to the following advantages:

i. Maintain humidity by a continuous film of water on the leaves, thus reduces transpiration and keeps the cuttings turgid.
ii. As humidity remains high, leafy cuttings are fully exposed to light and air.
iii. Protects against bright sunshine.
iv. Mist reduces disease infection in cuttings by removing fungus spores before they reach the tissues.

2.9 Greenhouse

A greenhouse is a semi-permanent structure coated in a transparent or translucent material, ranging from simple self-constructed designs to sophisticated pre-fabricated structures. Many types of green houses are used for propagation, but the most appropriate type is one that allows the highest amount of light to penetrate and where the environment could be adjusted to promote plant proliferation or growth. Proper lighting is necessary for the growth of seedlings. Experiments have shown that an east-to-west greenhouse provides the best light penetration in winter and early spring, making it ideal for producing seedlings during this time of year. Green houses should be located away from sources of shade, such as trees, buildings, and other greenhouses. A greenhouse frame can be made of wood, bamboo, steel, aluminum, with covers made of glass or a variety of rigid or flexible plastic materials. Greenhouses protect plants from harsh environmental conditions and also from pest damage. Environmental conditions inside a greenhouse can be adjusted to promote the growth of nursery plants. Modern greenhouses include advanced design and have precise control over temperature, light intensity, and humidity.

However, the level of environmental and climatic modifications will be determined by the design of greenhouse and, in general is related with its cost. The more the greenhouse's ability to adjust its climate, the higher is its building cost. Temperature, relative humidity, light, and carbon dioxide all have an impact on greenhouse environment. Greenhouses are grouped into different varieties based on their shape: naturally ventilated or saw-tooth type, tunnel type with side ventilation or Plastic Low Tunnels, and net houses, which include shade net houses and insect-resistant net houses.

Greenhouse size and type are mostly determined by plant propagation requirements. Glass-covered greenhouses are costly yet have a long lifespan. Plastic-covered greenhouses can provide short-term benefits. There are two plastics available for construction of greenhouse, namely polyethylene and fiber glass. Although plastic greenhouses are lighter than glass greenhouses, they have a higher level of humidity, especially during the winter months, causing unwanted water drops on plants. Adequate ventilation can help overcome this issue.
In greenhouses, two types of beds are utilized to raise seedlings. Greenhouse beds can be prepared on the ground, in raised beds, or on benches. The seedlings are raised inside greenhouse on raised beds or in plug-trays, for hardening of tissue cultural plants.

Check your progress

1. Discuss micro-propagation and its importance in nursery management.
2. What is misting units and how it is beneficial for the plant?
3. Explain greenhouse and its types.
4. Explain the working of misting units, installed in a nursery.

Summary

In this unit, we have discussed about weeding, its intensity, types and soil working. Weeding is an important operation which should be carried out timely in the nurseries. The soil of the bed should be prepared properly. This unit also covers the concept of transplanting, fertilization and different plant containers used in nursery operations. Transplanting is also called as lining out or pricking out. Transplanting to a large extent is done with the help of a transplanting board. Different types of containers are used in transplanting process. Fertilization is one of the most important aspects of raising high-quality nursery stock and are often sprayed just before or right after planting. You have also learnt about micro-propagation, misting units and greenhouse. Micropropagation using tissue culture techniques is one of the most recent vegetative propagation strategies. Micro-propagation employing the tissue culture approach offers unique capabilities to rapidly multiply elite trees via organogenesis or somatic embryogenesis. Misting is a technique for reducing moisture loss in plants, it provides more than 85% of relative humidity. Many types of green houses are used for propagation, it is a semi-permanent structure coated in a transparent material to protect plants from harsh environmental conditions and from pests.

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Unit 3: Type and Components of Nursery

Unit Structure

3.0 Learning Objectives

After the study of this unit, a learner would be able to:

- Describe the main aspects considered before raising the nursery
- Discuss the types of nurseries
- Discuss the structure and components of nurseries
- Explain the importance and types of greenhouses
- Discuss the factors on which environment of greenhouse depends
- Discuss the prerequisites for establishment of nurseries

3.1 Introduction

A nursery typically refers to a place where plants are grown and nurtured, especially young plants or trees. They play a vital role in the cultivation and propagation of plants, providing a best environment for young plants to thrive before being transplanted into gardens, landscapes, plantations, forests, or commercial establishments or settings. There are various types of nurseries, each serving different purposes and catering to diverse needs.

Further, nurseries consist of several key components that are essential for the successful propagation, growth, establishment and maintenance of seedlings, saplings of plant species. Understanding the types and components of nurseries is crucial for the stakeholder i.e, gardeners, students, learners and professionals of forestry and horticulture industry. In this unit, we will discuss the different types and components of nurseries that are essential in any plant nursery and on which success of plant cultivation or propagation depends.

3.2 Main Aspects to be considered before Raising Nursery

Before starting any business, there are several key aspects that should be considered to ensure a strong foundation for a thriving and establishing a sustainable business. This is also true for raising a nursery business also. These aspects include:

3.2.1 Market Research, Business and financial planning

In order to understand the demand for plant species for which nursery has to be established, a market research is conducted in the area and such plant species are identified which are in high demand. Further, it also helps to understand the preferences of potential customers, and any gaps in the market that a nursery owner may fill. This will help you to determine the viability and potential profitability of your nursery.

After conducting a market research, need is to develop a comprehensive business plan that outlines your goals, target market, marketing strategies, financial projections, and operational procedures so that purpose of establishing a nursery is ensured. A well-thought-out business plan will serve as a roadmap for your nursery and helpsa nursery owner to make an informed decision. A good business plan is the one that has good financial plan. Therefore, determining the financial aspects of the nursery, including the initial investment required, ongoing operational costs, pricing strategies, and projected revenue is needed beforehand. Consider factors such as plant sourcing, labor costs, utilities, marketing expenses, and potential risks. Develop a financial plan that accounts for these factors and ensures the financial sustainability of the nursery. Further, a marketing strategy is to be developed in order to promote your nursery and attract customers. This may include creating a website, utilizing social media platforms, attending local gardening events, collaborating with landscapers or garden centers, and offering exceptional customer service. Identify your target customers and tailor your marketing efforts to reach them effectively.

3.2.2 Location

Choose a suitable location for your nursery. Consider factors such as accessibility, proximity to target customers, availability of water sources, and the climate conditions that are favorable for the plants you intend to grow. Additionally, ensure that the location has enough space to accommodate your growing areas, storage facilities, and potential expansion.

3.2.3 Plant Selection

Plant selection i.e., the types of plants, to be grown in the nursery is one of the important steps which are to be considered for being successful in the nursery business. Factors such as local demand, market trends, and your expertise in cultivating specific plant species are to be considered for it. It is important to choose plants that are suitable for your climate and have a good market value.

3.2.4 Infrastructure and Equipment

Assess the infrastructure and equipment required for your nursery. This includes growing areas (greenhouses, shade houses, or open fields), irrigation systems, potting and container areas, propagation facilities, storage areas, and office space. Ensure that you have the necessary equipment and tools for plant care, maintenance, and propagation.

3.2.5 Legal and Regulatory Requirements

Familiarize yourself with the legal and regulatory requirements for operating a nursery in your area. This may include obtaining licenses, permits, and certifications, complying with zoning regulations, and adhering to environmental and safety standards. Consult with local authorities or seek legal advice to ensure compliance.

3.2.6 Knowledge and Expertise

Acquire the necessary knowledge and expertise in plant cultivation, propagation techniques, plant care, and pest and disease management. Stay updated with industry trends, attend workshops or training programs, and network with other horticulture professionals. Continuous learning and improvement will contribute to the success of your nursery.

3.3 Advantages of Modern Nursery Raising System

Modern nursery raising systems offer several advantages over traditional methods. Some of the key advantages include:

- **Increased Efficiency:** Modern nursery systems are designed to maximize efficiency in plant production. They often incorporate advanced technologies, such as automated irrigation systems, climate control systems, and precision planting equipment. These technologies help optimize resource utilization, reduce labor requirements, and improve overall productivity.
- **Improved Plant Quality:** Modern nursery systems provide better control over growing conditions, resulting in higher-quality plants. With precise control over

factors like temperature, humidity, and light, nurseries can create optimal conditions for plant growth, leading to healthier and more robust plants. This is particularly important for producing disease-resistant and high-yielding plant varieties.

- **Enhanced Disease and Pest Management:** Modern nursery systems often employ integrated pest management (IPM) techniques to minimize the use of chemical pesticides. IPM involves monitoring and identifying pests and diseases early on, implementing preventive measures, and using targeted treatments when necessary. This approach reduces the risk of pesticide residues, promotes environmental sustainability, and ensures healthier plants.
- **Year-round Production:** Traditional nurseries may be limited by seasonal variations and weather conditions. However, modern nursery systems, such as greenhouses or controlled environment agriculture (CEA) facilities, allow for year-round production. By providing a controlled environment, these systems enable nurseries to produce plants consistently, regardless of external factors like temperature or sunlight availability.
- **Increased Plant Variety:** Modern nursery systems offer the ability to grow a wide range of plant varieties, including exotic or rare species. With advanced propagation techniques like tissue culture or micro propagation, nurseries can rapidly multiply plants and produce genetically identical clones. This allows for the mass production of specific plant varieties, meeting the diverse demands of customers and expanding market opportunities.

Improved Water and Resource Management: Water scarcity and resource conservation are significant concerns in agriculture. Modern nursery systems often incorporate efficient irrigation methods, such as drip irrigation or hydroponics, which minimize water usage and reduce nutrient runoff. Additionally, technologies like rainwater harvesting and water recycling systems can further enhance water management practices in nurseries.

- **Scalability and Expansion:** Modern nursery systems are often designed with scalability in mind. They can be easily expanded or modified to accommodate growing demands or changes in market preferences. This flexibility allows nurseries to adapt to evolving market trends and seize new business opportunities.

- **Enhanced Data Monitoring and Analysis:** Modern nursery systems often integrate data monitoring and analysis tools. This enables nurseries to collect and analyze data on plant growth, environmental conditions, and resource usage. By leveraging this data, nurseries can make informed decisions, optimize production processes, and improve overall efficiency.

Overall, modern nursery raising systems offer numerous advantages that contribute to increased productivity, improved plant quality, and sustainable practices. These advancements help nurseries meet the demands of a growing market while minimizing environmental impact and ensuring long-term profitability.

3.3.1 Types of Nurseries

There are several types of plant nurseries, each specializing in different aspects of plant production and catering to specific customer needs. Some common types of plant nurseries include:

(A) Retail Nurseries: Retail nurseries are the most common type and cater to individual customers and homeowners. They offer a wide variety of plants, including ornamental plants, trees, shrubs, flowers, herbs, and vegetable seedlings. Retail nurseries often provide advice and guidance on plant selection, care, and maintenance.

(B) Wholesale Nurseries: Wholesale nurseries primarily supply plants to businesses such as landscapers, garden centers, municipalities, and other nurseries. They typically have a larger inventory and offer plants in bulk quantities. Wholesale nurseries may specialize in specific types of plants or cater to a wide range of plant varieties.

(C) Mail-Order Nurseries: Mail-order nurseries operate through catalogs or online platforms, allowing customers to browse and order plants remotely. The plants are then shipped to the customer's location. Mail-order nurseries often have a wide selection of plants and serve customers who may not have access to local nurseries.

(D) **Specialty Nurseries:** Specialty nurseries focus on specific types of plants or plant categories. They may specialize in native plants, rare or exotic species, succulents, roses, bonsai trees, aquatic plants, or specific plant families. These nurseries often have expert knowledge and a specialized collection of plants.

(E) **Organic Nurseries:** Organic nurseries specialize in producing plants using organic growing methods. They avoid the use of synthetic fertilizers, pesticides, and genetically modified organisms (GMOs). Organic nurseries cater to customers who prioritize environmentally friendly and sustainable gardening practices.

(F) **Fruit Tree Nurseries:** Fruit tree nurseries specialize in growing and selling fruit-bearing trees, such as apple, citrus, peach, or cherry trees. These nurseries often offer a wide selection of fruit tree varieties and provide guidance on proper planting and care to ensure successful fruit production.

(G) **Shade Tree Nurseries:** Shade tree nurseries focus on growing and selling large, shade-providing trees. These trees are often used for landscaping purposes in residential, commercial, or public spaces. Shade tree nurseries offer a variety of tree species suitable for different climates and growing conditions.

(H) **Container Nurseries:** Container nurseries specialize in growing plants in containers rather than in the ground. They offer a wide range of potted plants, including annuals, perennials, shrubs, and small trees. Container nurseries are popular for their convenience and flexibility, as potted plants can be easily transported and planted in various locations.

(I) **Hydroponic Nurseries:** Hydroponic nurseries utilize soilless growing techniques to cultivate plants. Hydroponic nurseries grow plants in nutrient-rich water solutions, while aquaponic nurseries combine hydroponics with aquaculture, using fish waste as a nutrient source for the plants. These nurseries are known for their efficient use of resources and year-round production capabilities.

It's important to note that some nurseries may specialize in multiple types of plants or offer a combination of services. The specific types of nurseries available may vary depending on the region, market demand, and local horticultural practices

3.3.2 On the Basis of Size

Plant nurseries can also be categorized based on their size or scale of operation. The size of a nursery can vary significantly, ranging from small-scale operations to large commercial enterprises. Here are some common categories based on size:

A) **Backyard or Home Nurseries:** These are small-scale nurseries operated by individuals in their own backyards or residential properties. These nurseries are typically run as a hobby or part-time business, focusing on a limited range of plants. Backyard nurseries often cater to local customers and may offer unique or specialty plants.

B) **Commercial Nurseries**

These nurseries are meant for the purpose of earning money through large scale production of plants. Based on the area involved in production process, these are again subdivided into following sub types:

- **Small-Scale Nurseries:** Small-scale nurseries are slightly larger than backyard nurseries and may operate on a dedicated plot of land or a small farm. These nurseries have a broader range of plants and may supply plants to local garden centers, landscapers, or individual customers. They may also participate in local farmers' markets or plant sales events.
- **Medium-Scale Nurseries:** Medium-scale nurseries have a more substantial operation and infrastructure. They typically have larger growing areas, greenhouses, and a wider range of plant varieties. These nurseries may supply plants to garden centers, landscapers, municipalities, and wholesale buyers. They may also have a retail section for direct sales to individual customers.
- **Large Commercial Nurseries:** Large commercial nurseries are extensive operations with significant land, infrastructure, and resources. These nurseries produce plants on a large scale and supply them to various markets, including garden centers, landscapers, municipalities, and wholesale buyers. They may have multiple growing areas, specialized facilities, and advanced technologies for plant production.

Another way of dividing commercial nurseries in based on the location of nursery whether it is in rural area or urban area, accordingly these are called as **rural nursery** and **urban nursery**.

The size of a nursery can impact its production capacity, market reach, and resources available for plant cultivation. It is important to note that the size of a nursery is not necessarily indicative of its quality or expertise. Nurseries of all sizes can provide high-quality plants and services, depending on their focus, management practices, and customer satisfaction.

3.3.3 On the Basis of Business

Plant nurseries can also be categorized based on the nature of their business operations. These categories reflect different business models and approaches to plant production and sales. Here are some common types of plant nurseries based on their business models:

- **Retail Nurseries:** Retail nurseries primarily focus on selling plants directly to individual customers and homeowners. They typically have a physical location, such as a garden center or nursery store, where customers can visit and purchase plants. Retail nurseries offer a wide variety of plants, including ornamental plants, trees, shrubs, flowers, herbs, and vegetable seedlings. They often provide advice and guidance on plant selection, care, and maintenance.
- **Wholesale Nurseries:** Wholesale nurseries specialize in supplying plants to businesses rather than individual customers. They primarily cater to garden centers, landscapers, municipalities, and other nurseries. Wholesale nurseries often have larger inventories and offer plants in bulk quantities. They may focus on specific plant varieties or cater to a wide range of plant types. Wholesale nurseries typically have different pricing structures and may require customers to meet minimum order quantities.
- **Online Nurseries:** Online nurseries operate primarily through e-commerce platforms or websites, allowing customers to browse and purchase plants online. These nurseries may have a physical location for plant production and fulfillment but rely heavily on online sales. Online nurseries offer a wide selection of plants and often ship

them directly to customers' locations. They may provide detailed plant descriptions, care instructions, and customer support through their online platforms.

- **Contract Growers:** Contract growers are nurseries that enter into contracts with businesses or organizations to grow plants on their behalf. They produce plants based on specific requirements provided by their clients. Contract growers may specialize in growing particular plant varieties or cater to the needs of specific industries, such as landscaping or municipal projects. They often work closely with their clients to ensure the plants meet the desired specifications.
- **Combination Nurseries:** Combination nurseries are businesses that combine multiple aspects of plant production and sales. They may have a retail section for direct sales to individual customers, while also supplying plants to wholesale buyers or offering contract growing services. Combination nurseries often have a diverse range of plants and cater to various customer segments. It is important to note that some nurseries may operate under multiple business models or offer a combination of services. The specific type of nursery business can vary depending on the market demand, target customers, and the nursery's specialization and business strategy.

3.4 Nursery Structures/Components

Plant nurseries consist of various structures and components that are essential for plant production, care, and management. These structures and components provide the necessary environment and infrastructure to support healthy plant growth. Here are some common structures and components found in plant nurseries:

3.4.1 Storage and Packing Areas

Storage and packing areas are used for storing plant materials, supplies, and equipment. These areas may include shelves, racks, or storage containers for organizing and storing pots, fertilizers, pesticides, tools, and other nursery supplies. Packing areas are used for packaging and preparing plants for transportation or sale.

3.4.2 Potting

Potting areas are designated spaces where plants are potted or transplanted into containers. These areas typically have workbenches, potting soil, pots or containers, and tools for potting and transplanting. Potting areas are essential for preparing plants for sale or further growth.

3.4.3 Nursery Beds

Nursery beds are raised platforms or containers where plants are grown. They can be made of wood, metal, or other materials and are filled with growing media, such as soil, peat moss, or a soilless mix. Growing beds or benches provide a suitable growing environment, facilitate drainage, and allow for easy access to plants for maintenance and harvesting.

3.4.4 Mist Chamber

A mist chamber is a specialized structure or enclosure used in plant propagation to create a controlled environment with high humidity levels. It is designed to provide optimal conditions for rooting cuttings or germinating seeds. Mist chambers are commonly used in nurseries, research facilities, and plant breeding programs.

The main purpose of a mist chamber is to maintain a high level of humidity around the plant material, which helps prevent excessive moisture loss through transpiration. This high humidity promotes the development of roots in cuttings or the germination of seeds. Mist chambers also provide a stable microclimate with controlled temperature and light levels, further supporting successful propagation.

3.4.5 Cold Frames

A cold frame is a simple and inexpensive structure used in gardening to extend the growing season and protect plants from cold temperatures, frost, and harsh weather conditions. It is essentially a low, enclosed structure with a transparent cover that allows sunlight to enter and traps heat inside. Cold frames are commonly used by gardeners, especially in cooler climates, to start seedlings early, harden off plants, or grow cold-tolerant crops during the colder months.

3.4.6 Hotbeds

Hotbeds are structures used in gardening to create a warm and controlled environment for seed germination and early plant growth. They are similar to cold frames but are specifically designed to provide heat to the plants. Hotbeds are commonly used to start seeds earlier in the season, promote faster growth, and extend the growing season.

3.4.7 Greenhouses

Greenhouses are enclosed structures made of transparent materials, such as glass or plastic that allows sunlight to enter while trapping heat inside. Greenhouses provide controlled environments for plant growth, protecting plants from extreme weather conditions and pests. They regulate temperature, humidity, and light levels, creating optimal conditions for plant growth. Greenhouses can be used for seed germination, propagation, and growing plants throughout the year.

3.4.8 Shade Houses

Shade houses are structures covered with shade cloth or other materials that provide partial shade to plants. They are used to protect plants from excessive sunlight and heat, especially in regions with high temperatures or intense sunlight. Shade houses allow for the cultivation of shade-loving plants or provide a transition area for plants before they are exposed to full sunlight.

3.4.9 Propagation Facilities

Propagation facilities are dedicated spaces for plant propagation, including techniques such as seed sowing, cutting propagation, grafting, or tissue culture. These facilities may have specialized equipment, such as misting systems, propagation beds, or growth chambers, to create optimal conditions for successful propagation.

3.4.10 Office and Administrative Spaces

Larger nurseries often have office spaces for administrative tasks, customer service, and record-keeping. These spaces may include desks, computers, filing cabinets, and other office equipment. Administrative areas are used for managing orders, inventory, sales, and other business operations.

These structures and components work together to create a functional and efficient environment for plant production, care, and management in nurseries. The specific structures and components present in a nursery can vary depending on its size, specialization, and the types of plants being grown.

3.5 Types of Greenhouses

The major types of greenhouses can be broadly categorized into passive greenhouses and active greenhouses. Here is an overview of each type:

3.5.1 Passive greenhouses

Passive greenhouses rely on natural elements such as sunlight, thermal mass, and airflow to create a stable and energy-efficient environment for plant cultivation. They do not rely heavily on mechanical systems for heating, cooling, or ventilation. The characteristics of passive greenhouses include utilization of design features like orientation for solar gain, thermal mass storage, natural ventilation, and insulation to maintain optimal growing conditions without active intervention. Examples are earth-sheltered greenhouses, Walipini greenhouses, and passive solar greenhouses are common examples of passive greenhouse designs.

a) **Earth-sheltered Greenhouses:** These greenhouses are partially or fully buried in the ground, taking advantage of the earth's thermal mass to regulate temperature. The soil acts as insulation, helping to maintain a more stable internal climate.

b) **Walipini Greenhouses:** Walipini greenhouses are partially underground structures with a transparent roof that captures sunlight. The design utilizes the thermal mass of the earth to retain heat and create a warm environment for plant growth.

c) **Attached Solar Greenhouses:** These greenhouses are attached to a south-facing wall of a building to capture solar heat. The building acts as a heat sink, absorbing and radiating warmth into the greenhouse during the day and night.

d) **Passive Solar Greenhouses:** These greenhouses are designed to maximize solar gain through orientation, glazing materials, and thermal mass. They rely on the sun's energy to heat the interior space without the need for additional heating systems.

e) **High Tunnel Greenhouses:** High tunnels are simple, unheated greenhouse structures covered with plastic or polyethylene film. They rely on natural ventilation and solar radiation to create a favorable microclimate for plant growth.

f) **Glass Greenhouse**: A glass greenhouse can be considered a type of passive greenhouse due to its reliance on natural light for plant growth. The glass covering of the greenhouse allows sunlight to enter the structure, providing plants with the necessary light energy for photosynthesis. This passive design feature eliminates the need for artificial lighting during daylight hours, reducing energy consumption and operating costs. Glass greenhouses have a classic and aesthetically pleasing appearance. They provide excellent light transmission and durability. Glass greenhouses are often used for high-value crops or in areas with extreme weather conditions. However, they can be more expensive to construct and require careful maintenance.

Additionally, glass greenhouses can also incorporate passive ventilation strategies, such as roof vents or windows, to promote natural airflow and regulate temperature and humidity levels. By utilizing natural light and ventilation, glass greenhouses can create a sustainable and energy-efficient growing environment for plants. A glass greenhouse can also be classified as a passive greenhouse due to its utilization of natural light and potential incorporation of passive ventilation systems. It is important to note that the term passive greenhouse can encompass a variety of design features beyond just the covering material, including insulation, thermal mass, and shading techniques etc.

These examples demonstrate various passive design strategies that can be incorporated into greenhouse structures to reduce energy consumption, promote sustainability, and create optimal growing conditions for plants.

g) **Net houses:** Net houses are also known as shade houses or screen houses. These are the structures used in agriculture, horticulture and forestry to provide protection to plants from various unfavorable or harmful factors such as excessive sunlight, wind, pests, and others. These structures are usually made from a framework covered with a specialized netting material that offers varying degrees of shade, ventilation, and protection. Some of the important features and uses of net houses are as follows:

i) **Control of shade and sunlight:** Shade house or net houses regulate the amount of sunlight reaching the plants. The netting material used in these structures can filter sunlight, reduce heat stress and prevent sunburn on delicate crops.

ii) **Ventilation and Airflow:** Natural ventilation and airflow is maintained inside the net houses thus, it creates adequate ventilation for plant species under propagation inside it. It also helps in maintaining optimal temperature and humidity levels inside the structure.

iii) **Protection from Insect-Pest:** The fine mesh of the netting material acts as a barrier against insect-pests and birds. Thus, it helps in protection of crops from damage and contamination.

iv) **Crop Protection:** Net houses provide protection against adverse weather conditions such as strong winds, heavy rain, and hail, safeguarding plants from physical damage and stress.

v) **Crop Specificity:** Net houses are used for a variety of crops including vegetables, fruits, flowers, and nursery plants. They are particularly beneficial for sensitive crops that require controlled growing conditions.

vi) **Cost-Effective Solution:** Net houses offer a cost-effective alternative to traditional greenhouses, providing growers with a practical and efficient way to protect and nurture their crops.

Overall, net houses play a crucial role in modern agriculture by offering a protective environment that promotes healthy plant growth, reduces crop losses, and enhances overall productivity. Their versatility and effectiveness make them a popular choice for growers looking to optimize growing conditions and maximize yields.

3.5.2 Active greenhouses

Active greenhouses incorporate mechanical systems such as heaters, fans, vents, and automated controls to actively manage temperature, humidity, and other environmental factors within the greenhouse. Active greenhouses rely on technology and equipment to regulate climate conditions, provide supplemental lighting, control irrigation, and optimize plant growth. They require ongoing energy input for operation. The examples of such greenhouses include High-tech greenhouses, hydroponic greenhouses, and **glass**

greenhouses with climate control systems are typical examples of active greenhouse structures.

a) **Plastic-Film Greenhouse:** Plastic-film greenhouses are cost-effective and widely used for various crops. They are constructed using metal or PVC frames covered with plastic film. Plastic-film greenhouses provide good light transmission and can be easily ventilated. However, they may require more frequent replacement of the plastic covering.

b) **High Tunnel/Greenhouse Tunnel:** High tunnels, also known as hoop houses or greenhouse tunnels are simple structures with a curved or semicircular shape. They are typically covered with plastic film and have no permanent foundation. High tunnels provide protection from the elements and extend the growing season. They are often used for season extension, crop experimentation, or small-scale production.

c) **Venlo Greenhouse:** Venlo greenhouses are commonly used in commercial horticulture. They have a modular design with a gable roof and a grid of vertical and horizontal supports. Venlo greenhouses often use glass panels for better light transmission and durability. They are designed for efficient use of space, optimal light distribution, and advanced environmental control.

Greenhouses can be also be classified into different types based on ventilation. Some common types include:

3.5.3 Natural Ventilated Greenhouses

Natural ventilated greenhouses rely on passive airflow mechanisms to regulate temperature and humidity inside the structure. These greenhouses are designed to take advantage of natural forces such as wind and convection to provide adequate ventilation for the plants. These greenhouses are popular for their energy efficiency and cost-effectiveness, as they rely on natural processes to maintain a healthy growing environment for plants. Key features of natural ventilated greenhouses include:

a) **Roof Vents:** These greenhouses typically have roof vents that can be opened or closed to control airflow. Hot air rises and escapes through the vents, creating a natural circulation of air.

b) **Side Vents:** Some natural ventilated greenhouses also have side vents that can be opened to allow fresh air to enter and circulate within the structure.

c) **Louvers:** Louvers are slatted openings that can be adjusted to control the amount of airflow entering the greenhouse. They help regulate temperature and humidity levels.

d) **Shade Cloth:** Shade cloth can be used to reduce the amount of sunlight entering the greenhouse, helping to maintain optimal growing conditions for plants.

3.5.4 Forced Ventilation Greenhouses

Forced ventilation greenhouses utilize mechanical systems such as fans to actively circulate air and control the environment inside the structure. These greenhouses are designed to provide precise control over temperature, humidity, and airflow to create optimal growing conditions for plants. Forced ventilation greenhouses are ideal for growers who require precise control over environmental factors and need to ensure optimal conditions for their crops. These systems are effective in regulating temperature, humidity, and air quality to promote healthy plant growth. Key features of forced ventilation greenhouses include:

a) **Fans:** Forced ventilation greenhouses are equipped with fans that help circulate air throughout the structure. Fans can be strategically placed to ensure uniform airflow and prevent stagnant air pockets.

b) **Air Ducts:** Ductwork is used to distribute air from the fans to different areas of the greenhouse. This helps maintain consistent temperature and humidity levels across the entire growing space.

c) **Thermostats and Sensors:** Automated systems with thermostats and sensors are often used to monitor environmental conditions and activate the ventilation system as needed. This allows for precise control over the greenhouse climate.

d) **Cooling Pads:** Some forced ventilation greenhouses may also incorporate cooling pads or evaporative cooling systems to help lower temperatures during hot weather.

3.6.5 Passive Ventilation Greenhouses

Passive ventilation greenhouses are designed to utilize natural forces such as wind, convection, and thermal buoyancy to regulate airflow and maintain optimal growing conditions for plants. These greenhouses do not rely on mechanical systems like fans or blowers for ventilation. Key features of passive ventilation greenhouses include:

a) **Roof Ventilation:** Passive ventilation greenhouses often have roof vents that allow hot air to escape and create a natural airflow pattern. The vents can be opened or closed to control temperature and humidity levels.

b) **Side Vents or Windows:** Some passive ventilation greenhouses also have side vents or windows that can be opened to allow fresh air to enter the structure. This helps promote air circulation and prevent overheating.

c) **Ridge Vents:** Ridge vents are openings along the peak of the greenhouse roof that allow hot air to escape. They take advantage of thermal buoyancy to create a natural convection current.

d) **Shutters and Louvers:** Adjustable shutters or louvers can be used to regulate the amount of airflow entering the greenhouse. They help maintain a balance between ventilation and temperature control.

While both **naturally ventilated greenhouses** and **passive ventilated greenhouses** rely on natural airflow mechanisms to regulate temperature and humidity, there are some subtle differences between the two terms. Naturally Ventilated Greenhouses refer to greenhouses that use natural forces such as wind and convection for ventilation. These greenhouses may include features like roof vents, side vents, or windows that can be opened to allow air circulation.

The term "naturally ventilated" emphasizes the reliance on natural airflow patterns whereas Passive Ventilated Greenhouses also refers to greenhouses that utilize natural forces for ventilation, but it may encompass a broader range of passive strategies beyond just airflow. Passive ventilation can include design features like thermal mass, insulation, and shading to help regulate temperature and humidity levels in a greenhouse. The term passive ventilation emphasizes the use of passive design elements to create a comfortable growing environment. In essence, while there is overlap between the two terms, i.e., passive green house and naturally ventilated greenhouses, however, the former encompass a wider range of passive design strategies beyond just ventilation whereas later term may focus more on the natural flow of air.

3.6.4 Mixed-mode Ventilation Greenhouses

Mixed-mode ventilation greenhouses combine both natural ventilation systems and mechanical ventilation systems to optimize airflow and temperature control within the structure. These greenhouses are designed to take advantage of the benefits of both natural and forced ventilation methods to create an ideal growing environment for plants.

Key features of mixed-mode ventilation greenhouses include:

a) **Natural Ventilation Components:** These greenhouses incorporate elements such as roof vents, side vents, or windows that can be opened to allow natural airflow when weather conditions permit. This helps reduce energy consumption and promote air circulation.

b) **Mechanical Ventilation Systems:** Mixed-mode ventilation greenhouses also include mechanical systems like fans or blowers that can be used when natural ventilation alone is insufficient to maintain optimal conditions. These systems provide additional control over airflow and temperature.

c) **Automated Controls:** Many mixed-mode ventilation greenhouses are equipped with automated controls that can switch between natural and mechanical ventilation modes based on environmental conditions. This ensures that the greenhouse maintains the desired climate for plant growth.

d) **Energy Efficiency:** By combining natural and mechanical ventilation strategies, mixed-mode ventilation greenhouses can achieve a balance between energy efficiency and precise environmental control. This can result in cost savings and improved crop yields.

Mixed-mode ventilation greenhouses are suitable for growers who want to leverage the benefits of both natural and mechanical ventilation systems to create a flexible and efficient growing environment for their plants.

3.6 Factors Affecting the Environment of Greenhouse

The environment of a greenhouse depends on several factors that need to be carefully managed to create optimal growing conditions for plants. Here are some key factors that influence the greenhouse environment:

3.6.1 Heat or Temperature

Temperature control is crucial in a greenhouse. The temperature affects plant growth, development, and overall health. Greenhouses use various methods to regulate temperature, such as ventilation, heating systems, shading, and insulation. Monitoring and maintaining the desired temperature range is essential for different stages of plant growth and specific plant requirements.

3.6.2 Humidity

Humidity levels influence plant transpiration, water uptake, and overall plant health. Greenhouses need to maintain appropriate humidity levels to prevent excessive moisture buildup, which can lead to fungal diseases. Humidity can be managed through proper ventilation, misting systems, and careful watering practices. Different plants may have specific humidity requirements, so it's important to consider their needs.

3.6.3 Light

Light is a vital factor for photosynthesis and plant growth. Greenhouses should provide sufficient light levels for optimal plant development. The amount and quality of light can be managed through the use of transparent or translucent coverings, shading systems, supplemental lighting, and proper positioning of plants within the greenhouse. Different plants have varying light requirements, so it's important to consider their specific needs.

3.6.4 Carbon Dioxide (CO_2) Levels

Carbon dioxide is essential for photosynthesis. Greenhouses may require supplemental CO_2 to enhance plant growth, especially in enclosed or low-ventilation environments. CO_2 can be supplied through burners, generators, or by introducing outside air. Monitoring and maintaining appropriate CO_2 levels can significantly impact plant growth and productivity.

3.6.5 Ventilation and Air Circulation

Proper ventilation is crucial for maintaining a healthy greenhouse environment. It helps regulate temperature, humidity, and carbon dioxide levels, and prevents the buildup of excessive heat, moisture, and stagnant air. Ventilation can be achieved through the use of vents, fans, louvers, or automated systems that open and close based on environmental conditions. Further, adequate air circulation within the greenhouse helps prevent stagnant air, reduces the risk of fungal diseases, and promotes even distribution of temperature, humidity, and CO_2. Fans or natural ventilation systems can be used to ensure proper air movement throughout the greenhouse.

3.6.6 Watering and Irrigation

Proper watering and irrigation practices are crucial for plant health and growth. Greenhouses may use various irrigation systems, such as drip irrigation, overhead sprinklers, or misting systems, to deliver water to plants. Watering schedules and techniques should be tailored to the specific needs of different plants, taking into account factors like plant size, growth stage, and environmental conditions.

3.6.7 Nutrient Management

Greenhouses often use soilless growing media or hydroponic systems, where nutrients are supplied through water. Proper nutrient management is essential to provide plants with the necessary elements for growth. Regular monitoring of nutrient levels and pH, along with appropriate fertilization practices, ensures optimal plant nutrition.

3.6.8 Pest and Disease Control

Greenhouses are susceptible to pests and diseases that can damage or destroy plants. Implementing integrated pest management (IPM) strategies, such as regular scouting, biological controls, cultural practices, and judicious use of pesticides, helps minimize pest and disease issues. Maintaining a clean and sanitized greenhouse environment is also important for preventing the spread of diseases.

3.6.9 Seasonal Considerations

Greenhouse environments may need adjustments based on seasonal changes. For example, shading systems may be used to reduce excessive heat during summer, while heating systems may be required to maintain warmth during winter. Monitoring and adapting to seasonal variations is essential for maintaining optimal growing conditions.

Managing these factors effectively and consistently is crucial for creating a favorable greenhouse environment that promotes healthy plant growth, maximizes productivity, and minimizes the risk of pests and diseases. Regular monitoring, adjustments, and attention to plant-specific requirements are key to successful greenhouse management.

3.7 Pre-requisites for Establishment of Nursery

Establishing a nursery requires careful planning and consideration of several prerequisites to ensure its success. Here are some key prerequisites to consider when setting up a nursery:

- **Knowledge and Expertise** in plant propagation, cultivation, and nursery management is essential. Familiarize yourself with different plant species, their growth requirements, propagation techniques, pest and disease management, and general nursery practices. Consider gaining relevant education or experience in nursery management to enhance your skills.
- **Market Research** is needed to identify the demand for plants in your target area. It is conducted in order to understand the preferences of potential customers, such as landscapers, garden centers, homeowners, or other nurseries. It helps in determining the types of plants that are in high demand and also helps in assessing the competition in the market.
- **Business Plan** is needed that outlines the purpose and goals of nursery establishment, target area, marketing strategies, financial projections, and operational details.
- **Site Selection–** Site selection is done beforehand. A number of factors are considered for this such as accessibility, proximity to target markets, availability of utilities (water, electricity), and the area etc. It should be ensured that the site has adequate space for plant production and storage etc.
- **Infrastructure and Facilities:** Assessment of the infrastructure and facilities required for the nursery is made. This may include greenhouses, shade houses,

irrigation systems, potting areas, storage facilities, and office space. Make a list of necessary equipment and tools for plant propagation, potting, and maintenance. It is also ensured that the infrastructure and facilities may be able to meet the specific needs of the plants planned to be grown in the nursery.

- **Legal and Regulatory Aspects:** One should understand the legal and regulatory requirements for establishing a nursery in an area. This may include obtaining necessary licenses, permits, and certifications. Environmental regulations and local regulations and specific requirements related to plant health and quarantine must be well understood.
- **Capital and Financing:** Capital is required to establish the nursery and also its operation. Cost of land acquisition, infrastructure development, plant materials, equipment, labor, marketing, and ongoing operational expenses should be calculated well beforehand. If required, homework for financing options such as personal savings, loans, grants, or partnerships etc. should be well planned.
- **Plant Material and Suppliers:** Identify reliable sources for plant materials, such as seeds, cuttings, or young plants. Establish relationships with reputable suppliers or consider developing your own propagation methods. Ensure that the plant material you acquire is of high quality and suitable for your target market.
- **Marketing and Sales Strategy:** A marketing and sales strategy should be ready in hand to promote your nursery and attract customers. This may include creating a brand identity, developing a website, participating in local events or trade shows, advertising, and building relationships with potential customers. Consider offering a diverse range of plants, competitive pricing, and excellent customer service to differentiate your nursery from competitors.
- **Staffing and Expertise** requirements for the nursery should be adequately assessed for skilled workers, such as propagators, sales staff, and administrative personnel. Hire employees with relevant expertise and provide ongoing training to enhance their skills and knowledge.

By addressing these prerequisites, one can lay a strong foundation for the nursery and increase the chances of its success. Remember to continuously adapt and improve your nursery operations based on market trends, customer feedback, and industry developments.

3.8 Why nursery is needed?

Nurseries play a crucial role in the forestry and horticultural industry and serve various purposes. Here are some reasons why nurseries are required:

- **Plant Production:** Nurseries are essential for the production of plants, including ornamental plants, trees, shrubs, flowers, and edible crops. They provide a controlled environment for seed germination, propagation, and growth of young plants. Nurseries produce a wide variety of plants to meet the demand of homeowners, landscapers, garden centers, and other customers.
- **Plant Availability:** Nurseries ensure a consistent supply of plants throughout the year. They grow plants in different stages of development, allowing customers to find plants at various sizes and maturity levels. Nurseries provide access to plants that may not be readily available in the wild or in local ecosystems.
- **Plant Diversity:** Nurseries contribute to plant diversity by cultivating a wide range of plant species, varieties, and cultivars. They offer a diverse selection of plants with different colors, sizes, shapes, and growth habits. Nurseries play a vital role in preserving and promoting biodiversity by growing and distributing rare, endangered, or native plant species.
- **Landscaping and Garden Design:** Nurseries provide plants for landscaping projects, garden design, and beautification purposes. They offer a wide selection of plants suitable for different landscape styles, climates, and soil conditions. Nurseries help homeowners, landscapers, and garden designers find the right plants to create visually appealing and functional outdoor spaces.
- **Environmental Benefits:** Nurseries contribute to environmental conservation and sustainability. They promote the use of plants for erosion control, habitat restoration, air purification, and carbon sequestration. Nurseries also encourage the cultivation of native plants, which support local ecosystems, attract pollinators, and provide food and shelter for wildlife.

- **Education and Research:** Nurseries often serve as educational centers, providing information and resources on plant care, gardening techniques, and horticultural practices. They may offer workshops, seminars, or educational programs to promote gardening knowledge and skills. Nurseries also collaborate with researchers and contribute to plant breeding, disease resistance studies, and other horticultural research.
- **Economic Impact:** Nurseries have a significant economic impact, generating revenue and employment opportunities. They contribute to the local economy by creating jobs in plant production, sales and landscaping etc.
- **Community Engagement:** Nurseries often serve as the places for community gathering, attract gardening enthusiasts, plant lovers, and nature lovers. They provide a common space for people share ideas, knowledge, and also helps in spreading awareness among people. Events such as plant sales, workshops, trainings, seminars, students' visits can be organized in order to foster a sense of community and environmental stewardship.

Overall, nurseries are needed to meet the demand for plants, provide plant diversity, support landscaping and garden design, promote environmental benefits, facilitate education and research, contribute to the economy, and engage communities in gardening and horticulture. They play a vital role in enhancing the beauty of our surroundings, improving the environment, and enriching our lives through plants.

3.9 Planning and Layout of Nursery

Planning and layout is n important step in nursery establishment. A well-designed nursery layout ensures efficient operations, optimal plant growth, and a productive working environment. Some key points that should be considered while making a plan and lay out a nursery are as follows:

- **Site Selection:** A suitable location for your nursery is selected. Factors such as accessibility, proximity to target markets, availability of utilities (water, electricity), and the size of the site are considered. It is also ensured that there should be adequate space for plant production, storage, and future expansion.

- **Nursery Zones:** Nursery is divided into different zones based on the specific needs of plants and operational needs. Common zones include propagation area, growing area, potting area, storage area, office area, and customer area. This kind of zoning helps in better management of differed activities and also ensures efficient use of space.
- **Greenhouse or Shade House Placement:** If you plan to use greenhouses or shade houses, determine their placement within the nursery. Consider factors such as sunlight exposure, wind direction, and accessibility. Position the structures to maximize sunlight exposure and minimize shading from nearby buildings or trees.
- **Infrastructure and Facilities:** Assess the infrastructure and facilities required for your nursery. This may include greenhouses, shade houses, irrigation systems, potting areas, storage facilities, and office space. Ensure that the infrastructure and facilities meet the specific needs of the plants you plan to grow. Plan for adequate space for plant production, potting, plant storage, and equipment storage.
- **Pathways and Access:** Design pathways and access points that allow easy movement of people, equipment, and plants within the nursery. Ensure that pathways are wide enough to accommodate carts, wheelbarrows, or other equipment. Consider using materials like gravel or concrete for pathways to facilitate easy cleaning and maintenance.
- **Water Supply and Irrigation:** Plan for a reliable water supply and irrigation system. Ensure that water sources are easily accessible and that irrigation lines are strategically placed to provide adequate water to plants. Consider using automated irrigation systems to ensure efficient water usage and minimize labor requirements.
- **Plant Display and Sales Area:** If you plan to sell plants directly to customers, allocate space for a plant display and sales area. Design an attractive and organized display area that allows customers to easily browse and select plants.

Consider providing shade structures, benches, or tables for customers to comfortably view and purchase plants.

- **Equipment and Tool Storage:** Allocate space for storing nursery equipment, tools, and supplies. Designate an area for equipment maintenance and repair. Ensure that storage areas are organized and easily accessible to facilitate efficient operations.
- **Office and Administrative Area:** Allocate space for an office or administrative area where you can manage nursery operations, handle paperwork, and communicate with customers and suppliers. Include a desk, computer, filing cabinets, and other necessary office equipment.
- **Safety Considerations:** Ensure that safety measures are incorporated into the nursery layout. Designate areas for storing hazardous materials, such as pesticides or fertilizers, and ensure they are properly labeled and secured. Install safety equipment, such as fire extinguishers and first aid kits, in easily accessible locations.
- **Future Expansion:** Consider future expansion possibilities when planning the layout. Allow for additional growing areas, storage space, or infrastructure as your nursery grows. This will help accommodate increased production and potential changes in business needs.

When planning the layout, it is essential to consider the specific requirements of your nursery, the types of plants you will be growing, and the workflow of your operations. Regularly review and adjust the layout as needed to optimize efficiency and productivity.

Summary

Before starting a nursery business, it is essential to consider several key aspects to ensure a thriving and sustainable venture. These include conducting market research, developing a comprehensive business plan, determining the financial aspects of the nursery, and developing a marketing strategy to promote the nursery and attract customers. After this step, if we have decided that we have to start this venture, then a suitable site / location for this establishment would be required. While choosing a suitable location for the nursery, considering factors such as accessibility, proximity to customers, availability of water sources, and favorable climate conditions etc. are given due importance. Those plant species are chosen which are suitable for the climate and have a good market value. Assess the infrastructure and equipment required for your nursery, including growing areas, irrigation systems, potting and container areas, propagation facilities, storage areas, and office space.

Familiarize yourself with the legal and regulatory requirements for operating a nursery in your area, such as obtaining licenses, permits, and certifications, complying with zoning regulations, and adhering to environmental and safety standards. Consult with local authorities or seek legal advice to ensure compliance.

Acquire the necessary knowledge and expertise in plant cultivation, propagation techniques, plant care, and pest and disease management. Stay updated with industry trends, attend workshops or training programs, and network with other horticulture professionals. Continuous learning and improvement will contribute to the success of your nursery.

Modern nursery raising systems offer several advantages over traditional methods, such as increased efficiency, reduced costs, and improved customer service. By focusing on these aspects, one can create a successful and sustainable nursery business.

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Unit 4: Nursery Tools and Nursery Equipments

4.0 Learning Objectives

After completion of this unit, you will be able to:

- identify the tools and equipments used in nurseries;
- understand the concept of soil treatment;
- describe seed treatment;
- discuss different kinds of soil less media;
- understand seed sowing and requirements for germination.

4.1 Introduction

Different kind of tools and equipments are used in nursery for carrying out various operations from the beginning to the end of seedling raising process. In olden days, tools were made of bones, wood, stones and metals. However, with the advancement of science and technology, the use of metals like copper, steel and iron has led to the development of various kinds of tool and equipments used in preparation of beds to uprooting and transplanting of seedlings in the main field.

4.2 Nursery tools and equipments

Many different equipment, tools, and accessories are required in the nursery to carry out regular cultural operations on daily basis. The various functions of these tools and equipment aid in the timely, easy, efficient, and cheap completion of daily farm activities. These tools have completely changed gardening and farming around the world. Some tools are basic and are meant to do simple operations, while other equipments are needed to perform certain tasks. Below is list and brief descriptions of these are given:

4.2.1 Tools used for land preparation

The first step in the process of land preparation involves breaking of hard soil surface, uprooting prior crop leftovers, and pulverizing the soil. Ploughing can be done with a variety of ploughs. Mouldboard, disc plough, rotary and sub-soil ploughs are some of the tools used for breaking the hard soil.

4.2.1.1 Mouldboard plough

It is composed of carbon or steel alloy, with a right-angled triangle base. The breadth of the furrow determines the size of a mouldboard plough. It can typically open a furrow that is at least 20 cm wide. It might only slice the furrow on one or two sides of the motion.

4.2.1.2 Disc plough

It is made up of rotating, circular steel discs in different sizes. Discs used in various ploughs have a diameter ranging from 50 to 90 cm. The thickness of discs can range from 2.5 cm at the cutting edge to 40 cm in the center. Certain discs have an edge thickness of 7.5 cm and a central thickness of 20 cm. Both hard and dry soils and sticky soils can be worked using the plough (**Fig.1**).

Fig. 1. Disc plough
Source: https://bit.ly/42TtnZS

4.2.1.3 Rotary plough

It is a tool used for breaking weeds or soil with the help of several blades fixed on a shaft. It is a main tillage instrument made up of a series of blades or tines that are powered by a source of rotation on a shaft (**Fig. 2**).

Fig. 2. Rotary plough
Source: https://images.app.goo.gl/gnrUsLfLjynTXSXA8

4.2.1.4 Sub-soil single arm plough

This plough has a single adjustable

arm with a base shear and works well in heavy soils. It breaks the hard pan that has formed beneath the soil surface. It enhances drainage and can be inserted up to 50 cm deep in the ground and works well in 5 to 7 cm broad trench.

4.2.2 Implements used for other basic works

Some important tools used in nursery are given below:

4.2.2.1 Harrow

Harrow is employed for thorough tillage of the soil by loosening up and levelling the hard surface that is perfect for seeding. Chain-disc, disc, tine (including spring-tooth), and chain harrows are the four types of harrows used in nursery operations. Disc harrow is used for deep ploughing and turning of soil, weeds, agricultural leftovers, and other detritus in the soil (**Fig. 3**).

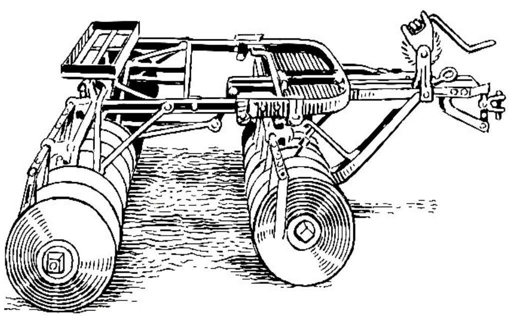

Fig. 3. Harrow
Source: https://images.app.goo.gl/aS8wHBx1VJBcgTqH9

4.2.2.2 Plank

The most essential operations for sowing, planting and irrigation of crops is levelling the field and smoothening of the soil surface. Wooden plank, patela, and level boards are some of the equipments that are utilized to complete these tasks quickly and efficiently. Usually, levelling is completed in two stages.

4.2.2.3 Cultivator

It is an efficient tool for tilling soil that is pulled by a tractor. It has high-quality carbon tyres with varying diameters based on the depth of the plough. Nowadays, small cultivators that are operated by hand are more common. It has a ploughing depth of ½ to 1 foot. It is used to break up clods in the soil, loosen it, and get rid of weeds that are growing in it.

Fig. 4. Cultivator
Source: https://images.app.goo.gl/mcuv8Hgrhh1Kkixm8

Harrowing and intermediate ploughing are done by cultivators. It also keeps the pH balanced, promotes aeration, eliminates runoff, and reduces evaporation losses. There are three types of cultivators: shovel, disc, and blade. To achieve a fine tilth, the soil is worked with tine and spike cultivators (**Fig. 4**).

4.2.2.4 Mower

In fields and lawns, grass is cut with a mower. High-carbon steel is used to make the mower's discs or blades. Field grass and weed plants are chopped with discs, that rotates rapidly and are spirally arranged on a central shaft. A progressive cutting action is produced across the anvil blade by the rotating cutting blades with spiral mounting. The anvil blade is a flat, adjustable blade with edges that have been honed. Shearing action traps and cuts grass and weed plants in between the sharp, revolving blades (**Fig. 5**).

Fig. 5. Mower
Source: https://images.app.goo.gl/2pp5zDTNd3XX6A3E6

4.2.2.5 Bill hook

It is commonly called as darat and is hook-shaped tool with a single or double cutting edge, made up of a curved blade fixed to a wooden or plastic grip. The blade is composed of manganese and high-carbon steel. The blade measures 2 cm in width and 13 cm in length. A bill hook is used to prune old or dead tree branches and trim plants (**Fig. 6**).

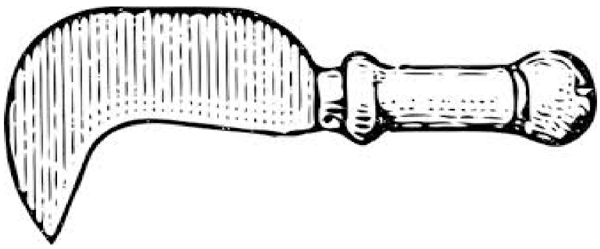

Fig. 6. Bill hook
Source: https://images.app.goo.gl/evxYj3JYVDfNrgeN6

4.2.2.6 Crow bar

One end of crow bar is pointed and other is wedge shaped. It is an iron rod, used for digging and removal of huge or heavy rocks from the ground.

4.2.2.7 Spade

Spade is made of cast iron and is used for small-scale gardening, to dig, lift and turn the soil. It is also used in channel preparation for irrigation and drainage lines (**Fig. 7**).

Fig. 7. Spade
Source: https://images.app.goo.gl/omCSX4tiP2pYUUabA

4.2.2.8 Garden hoe

The handle is lengthy and has a blade and paddle at the end. It may be used to cultivate garden soil and perform weeding tasks. There are various types of garden hoe designed for particular purposes, like hoe-cum-rake. It is a metal blade in the shape of a rectangle with a fork-like front edge. It is employed for weed collection, earthing, hoeing, and excavating.

4.2.2.9 Garden rake

A rake is used to remove weeds, stones, brick bits, and fallen leaves from the bed. It helps in creating a fine tilth on the soil's surface in order to prepare it for seeding. For these kinds of tasks, a toothed rake is always preferable (**Fig. 8**).

Fig. 8. Garden rake
Source: https://images.app.goo.gl/HRsBp8vjRJUdfwdt8

4.2.2.10 Trowel

It has a wooden handle and an iron blade, resembling a little shovel and is called as kurphi. It is designed to be used for weeding, hoeing, lifting plants and seedlings at a nursery, and to carry out different gardening tasks. It can be manufactured in a variety of shapes as per local designs and requirements.

4.2.2.11 Sickle

Sickle is used for cuttings grasses and leafy vegetables (**Fig. 9**).

Fig. 9. Sickle
Source: https://images.app.goo.gl/XJ7ypdhkaXm6XDDn7

4.2.2.12 Kudali

It is a basic but important tool used for digging of soil, pits or any work which occurs before nursery bed preparation. It has a hardwood handle with a metal (iron) blade attached and is manually operated.

4.2.2.13 Shovel

Its wooden handle and spoon-shaped iron blade are used for transporting soil within the field to prepare it for planting nursery beds.

4.2.2.14 Axe

Axe is usually used for cutting and felling of trees and branches (**Fig. 10**).

Fig. 10. Axe
Source: https://images.app.goo.gl/V1MsMgG55gnp85Yt7

4.2.2.15 Sprayer or Spray-pumps

Spray pumps are very important tools to spray protective material like insecticides, fungicides, herbicides, fertilizers and various other chemicals in a field. Pumps come in a variety of sizes and forms. Knap-sack sprayer, rocker sprayer, hand sprayers or power sprayers and foot sprayer are some of the commonly used sprays. Depending upon the volume of nursery and special purpose, a variety of sprayers are available in the market.

4.2.2.16 Watering can

It is used for irrigating annual flowers, vegetables and newly transplanted seedlings to prevent damage to young seedlings and also protect the soil from being washed away.

4.2.2.17 Wheelbarrow

It is used to collect trash in the garden and to move heavy things from one place to another like nursery plants, compost, fertilizes, leaf litter, horticultural produce and stones. On the basis of requirements, it can be created into a variety of shapes (**Fig. 11**).

Fig. 11. Wheelbarrow
Source: https://images.app.goo.gl/zro6JrJzJBC6h3dE8

4.2.3 Tools used in grafting and budding

Several tools are used in the process of grafting and budding. Some of the important tools are explained below:

4.2.3.1 Budding-cum-grafting knife

A combination of two knives used for both grafting and budding process is called a budding-cum-grafting knife. It is made up of two blades: one for grafting and the other for budding. The ends of a handle are attached to these knives. Steel with alloy or high carbon content is used to make both knives and these knives typically have a fixed or folding blade. The knife may have a length of 6.5-7.5 cm and a width of 1.5 cm.

4.2.3.2 Secateur

The most essential instrument for propagation is secateur and is employed in training and pruning procedures, scion removal, lopping off the rootstock, scion stick preparation, and the removal of undesired shoots or sprouts from the stock. The best secateurs should have premium carbon blades to ensure that the stock and scions are cut smoothly (**Fig. 12**).

Fig. 12. Secateur
Source: https://images.app.goo.gl/sfijUKDEBdCV235W8

4.2.3.3 Pruning shear

It has a wooden handle and is made of iron. It serves in pruning of undesirable branches, trimming of hedges and margins, and collecting scion. Different types of shears like hand shears, lopping shears, tree trimmers are used in nursery.

4.2.3.4 Pruning saw

It is used in pruning and propagation of horticultural plants. Commonly used pruning saws are crescent saws, tapered saws and straight saws. All are equipped with long, widely spaced teeth that make trimming and chopping green wood easier. Its blades ought to be thin in order for it to squeeze through

Fig. 13. Pruning saw
Source: https://images.app.goo.gl/zanR9QTQHJpojdVh7

branches that are tightly spaced or thin (**Fig. 13**).

4.2.3.5 Seedling trays

These are mostly utilized for germination of various horticultural crop seeds and for hardening the micro propagated plants. These trays range in size from 25 to 250 cavities, depending on the quantity of cavities. The seedling trays with varying capacities can be selected by the propagators based on their requirements and the type of crop to be grown (**Fig. 14**).

Fig. 14. Seedling trays
Source: https://images.app.goo.gl/jYmRw4wBeAYwXb377

There are several other tools and equipments present in the market that are used in nursery operations these are ladder, pruning or slashing knife, hedge shear, grass shear, garden rake, tree pruner, flower scissors or cutters. Various tying and wrapping material are used in grafting and budding that includes waxed string and cloth, raffia fiber, rubber and polythene strips.

4.3 Soil treatment

The soil of nursery bed should be light, cohesive and rich in organic matter. It is very important to treat nursery soil to produce healthy disease-free seedlings, as most of the diseases are soil borne. Basically, the soil utilized in nursery contains harmful pathogens that are detrimental to the growth and development of the seedlings. When pests are present in the soil, there is a significant loss to the crops grown in the nursery and the infection can migrate to the field through seedlings or clinging media on the roots. As a result, it is recommended that the harmful pathogens should be eliminated from the soil through various methods like soil-pasteurization, soil solarisation and treating soil with chemicals and bio-agents. Different methods of soil treatment are given below:

4.3.1 Soil solarisation

Controlling soil-borne plant pathogens, such as bacteria, fungi, nematodes, insect pests, and weeds, can be done in an environmentally friendly manner. In this method, soil temperature is raised around 5-8°C with the help of solar radiation, which helps in the suppression of numerous soil-borne diseases. The soil is covered by transparent plastic sheet for 3-4 weeks on the beds and April - June is the best time for soil solarization due to high temperature (45°C or above). In this process, soil undergo various chemical, biological, and physical changes.

4.3.2 Soil treatment by different chemicals

Chemicals like formaldehyde, sodium methyl, and methyl bromide are commonly used to sterilize soil. In our country, methyl bromide and sodium methyl are prohibited by law and cannot be used. Therefore, soil is sterilized by using **formalin** solution.

Soil is also treated by using fungicides like **captan** or **thiram** to control soil-borne pathogens. To kill insects, ants, nematodes, white ants and their eggs ***chloropyriphos***, an insecticide is used. ***Trichoderma*** is a biological agent used to control soil-borne pathogens is mixed in the soil before seed sowing.

4.3.3 Soil-pasteurization

Soil-pasteurization is done at 60°C for 30 minutes to kill harmful organisms present in the soil. However, this technique also eliminates a number of beneficial soil microorganisms. As a result, steam pasteurization is popular nowadays, which exclusively destroys dangerous pathogens. Furthermore, this method is not employed by the common man because it requires expensive instruments.

Check your progress

1. Explain different tools used for land preparation.
2. Name some of the basic tools used in nursery operations.
3. Write the difference between pruning saw and pruning shear.
4. Why soil treatment is important?
5. Explain different methods of soil treatment.

4.4 Seed treatment

Some seeds require pre-treatment, as they pass through dormancy during which the physiological maturity of the embryo is attained. The nature of pretreatment depends on the hardness of the seed coat. If contaminated seeds are planted, they might not germinate effectively, and if they do, the seedlings might grow slowly and possibly die soon after. Seeds which have soft seed-coats generally do not need any seed pre-treatment. However, it is always advisable to put the seeds in water for 24 hours and dry them in the shade before sowing. Some of the methods of pre-treatment are given below:

4.4.1 Soaking in cold water

Soaking in water is the most popular treatment for a number of species. The seeds are soaked in cold water for one to several days depending upon the hardness of the seedcoat. Water absorbed softens the seed coat. When soaking is required to be done for a long period, it is advisable to change the water regularly. Water soaking for most of the species is advantageous also even when no exogenous dormancy is noticed. After soaking, treatment seed should be sown without loss of time as the drying seriously reduces the viability of seed.

4.4.2 Soaking in hot Water

Seeds of leguminous trees have extremely tough seed coat which will restrict germination for years together unless hot water treatment is applied. Seed is immersed in two to three times its volume of boiling water and allowed to soak until it turns cold.

4.4.3 Acid treatment

Seeds with hard, smooth shiny coats are not difficult to germinate and the germination percent is also quite high. Germination period of these species is spread over some weeks. The most effective method of obtaining quick germination is to soak dried seeds in concentrated H_2SO_4 for varying period. After soaking, the seed must be immediately washed in clean water. For each species, period for soaking should be worked out as over exposure can seriously damage the seed.

4.4.4 Disinfestation

It is a process that removes organisms from the surface of the seed. To prevent infections from spreading to the seedbeds, a lot of chemicals are used to sterilize the seeds before they are sown. The most often used disinfestation are mercuric chloride, calcium hypochlorite, and ethanol alcohol. The size and kind of the seeds mostly determine the concentration and timing of the treatment. Depending on the size and type of seed, the treatment may last between 5 - 30 minutes. Prolonged exposure of the seeds to disinfestants should be avoided, as this could harm the embryo and impair germination. The seeds are immediately sown in the nursery after receiving chemical treatment and being rinsed with tap water.

4.4.5 Disinfectations

It involves treatment of seeds in such a manner that the pathogens reside within the seeds gets eliminated. Hot water treatment and treatment of seeds with formaldehyde and mercuric chloride works best for disinfection.

4.4.6 Seed treatment with Bio-agents

To produce healthy seedlings in the nursery, the seeds are treated with *Trichoderma* species prior to sowing.

Check your progress

1. Why seed treatment is important?
2. Differentiate between Disinfestation and Disinfectation.
3. Explain different methods of seed treatment.

4.5 Soil-less Media for Nursery Raising

Soil less media is very useful in raising seedlings of any species in nursery. Another important component used in nursery plantation is growing medium.

Growing medium

Different substrate or medium used to grow plants is called growing medium. It supplies nutrients, air and water to the roots of plants, thus facilitates maximum root growth provides water and physical support to plants. Growing medium must have adequate aeration, drainage and water-holding capacity. The pH of medium ranges from 6-6.5 and is free of weeds, pests and pathogens. The growth of the plant is influenced by the chemical and physical properties of the medium. Different types of growing medium such as garden soil, compost, sand, sphagnum moss, peat, coca peat, vermiculite, perlite and sawdust are used as per the requirement of plants.

4.5.1 Soil-less media

To grow healthy and vigorous seedlings of vegetable crop in plastic pro-trays, artificial soil-less media is basically required. A combination of three ingredients- cocopeat, vermiculite, and horticultural perlite is utilized as the root medium. Before adding the components to the necessary containers or plastic pro-trays, they are combined in a 3:1:1 ratio. Coarser-textured peat media improve drainage and aeration, which in turn promotes greater root formation in transplants. Soil-less media such as coca peat, vermiculite and perlite are discussed below:

4.5.1.1 Coca peat

It is made with the leftover coconut husk. This media is acidic in nature, a pH value of 5 and offers enhanced air movement activity, better drainage. There is not a single bug or disease infestation on this media. Coco-peat is frequently used as a medium for growing vegetable and ornamental plant nurseries as well as for the sheltered cultivation of decorative crops.

4.5.1.2 Vermiculite

Chemically hydrated magnesium, aluminum, and iron silicate is known as vermiculite. It is created by heating mica. The folded structure associated with this mineral is produced by heating it around 1,400°F or 760°C. It weighs relatively little, has a strong water-holding capacity, and contains minerals like potassium and magnesium to enhance the mixture. The biggest particles are found in grade 1, whereas the textures of grades 4 and 5 are fine. The grades 2 and 4 are the most often utilized ones. In addition, because of its fineness, it can readily get compressed in a mixture. A mixture that contains vermiculite should not be compacted too firmly to limit its possibilities.

4.5.1.3 Perlite

It is a thin layer of light volcanic rock. In essence, it is aluminum silicate rock that has been heated. To create the white granular product, the volcanic ore is roasted to extremely high temperatures-roughly 1800°F. This causes the rock particles to expand. Its function in a mix is to enhance drainage and aeration. The horticultural grade of this item should be chosen if it is going to be used in a mix since it has a larger particle size and is therefore more effective. With the exception of trace levels of sodium and aluminum, perlite reacts neutrally and adds very little nutritional value to the mixture. The fact that perlite floats when, the medium is wet makes its low weight a limiting factor. Additionally, it creates dust when mixing, which is removable. The major advantages of soil-fewer medium include uniformity of mix, ease of handling, versatility, sterility, ready to use, good drainage and better moisture retention.

4.6 Sowing of Seeds

Seeds should be sown in seed flats or in germinating beds if they are of small size. Sowing of seeds in beds is either done by broadcast method, drilling or dribbling. Dibbling is done for large sized seeds which can also be sown by drilling. Usually, broadcasting is practiced for small sized seeds. Very small seeds are mixed with sand, soil or wood ash for uniform settling on the soil surface. Medium and large sized seeds may be broadcasted without any medium. Line seeding or drill sowing is advantageous as it facilitates weeding and hoeing. Closeness of sowing lines and seed in the line depends upon the germination capacity of the seeds and or whether entire transplants are used or whether root-shoot cuttings are needed. For large sized seeds, sowing is done along lines, each seed touching the next. The depth of sowing should be equal to 2 or 3 times the diameter of the seed, if the seeds are known to have a comparatively long germination time, the sowing should be deeper, though the soil cover should not be compacted. Seeds can be sown deeper in light soils than in heavy soils.

4.7 Requirements for Germination

The process of germination is done in greenhouses for subsequent transplantation in the greenhouses or open fields. When seeds are sown in greenhouses, germination rates are extremely high. Likewise, plants propagated in greenhouses are of higher quality than those grown in open fields. Even in greenhouses with controlled environment, certain microenvironment is necessary for the proper germination of some finer seeds. The plastic or glass covers are taken off after the seeds begin to germinate in order to keep the developing plants from etiolating. When ready, these seedlings are placed in small containers to establish themselves before being placed in larger containers or in fields. Seed germination is an extremely complex process as it entails several biochemical, physiological and morphological changes within a seed. Three requirements need to be achieved in order for germination to start.

i. The embryo must be alive and able to germinate.
ii. Second, the seed must not be dormant, meaning that there should be no chemical barrier or dormancy.
iii. Third, the right amount of moisture, temperature, air (O_2), and light must be present in the environment.

The process of seed germination requires several stages; however, the main 3 stages are Activation or awakening stage, Translocation stage and Seedling growth stage. Seeds germinate through radicle and plumule parts.

Check your progress

1. Explain growing medium.
2. Differentiate between vermiculite and perlite.
3. Explain coca peat and the importance of soil-less media.
4. What do you understand by seed germination and how it was achieved?
5. Discuss about sowing of seeds.

Summary

In this unit, we have discussed about different tools and equipments that are used in land preparation, grafting and budding process and for other basic operations performed in the nursery. This unit also covers the concept and importance of seed and soil treatment. Basically, the soil utilized in nursery contains harmful pathogens, so to eliminate these harmful pathogens from the soil various methods like soil-pasteurization, soil solarisation and treating soil with chemicals and bio-agents are done. Similarly, seed treatment is also very important and is performed by various methods. This unit describes about soil less media and various soil-less media such as coca peat, vermiculite and perlite that are common in use. This unit summarizes about seed sowing and the basic needs for seed germination.

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Unit 5: Establishment of Nursery-I

Unit Structure

5.0 Learning Objectives

After you have studied this unit, you should be able to understand about:

- Low cost nursery practices
- Learn about modern nursery raising procedures.

- Understanding transplant components.
- Learn about labeling and packing of nursery materials.

5.1 Introduction

Several more effective methods have been created and established for nursery raising in various horticultural crops, particularly vegetable crops, because the old nursery raising system is incapable of resolving numerous problems that arise during nursery raising. Similarly, various additional techniques, such as the use of plastic mulch, tiny greenhouses, shade nets, and insect proof nets, have improved the traditional nursery rearing system.

As a result, individual producers must be completely aware of the latest nursery growing techniques. Common farmers can employ inexpensive technology, whereas progressive educated farmers can use a more modern system. However, before using the modern system, complete knowledge of all the components of the modern nursery raising system, viz., use of insect proof nets, shade nets, use of PGRs, height control in plug tray system, fertigation in plug tray seedlings, quality of water required for fertigation, preparation of stock solution, frequency of injection or fertigation, hardening of seedlings, disease management in seedlings, and packing of seedlings for transporting them over long distances.

5.2 Low - Cost Nursery Techniques

Several improvised methods have been created and attempted, and they have proven beneficial for small and medium-sized plant farmers. Some of the more successful types are:

5.2.1 Seedlings Raising in Plastic Bags

This technology allows that a high number of seedlings can be produced in a small space under optimal and controlled conditions. The seeds, saplings, or cuttings are planted in plastic bags containing a carefully prepared potting mix. The bags have holes on their bottoms. They are kept in shallow holes lined with plastic film to keep the roots from reaching the earth below. Water is poured into the pit and then into the bags through the apertures. The potting medium must be permeable to prevent water logging and contain essential plant nutrients.

Normally, 1:1:1 ratio of soil, sand (or crushed stone), and compost is utilized; however, if the soil is sandy, the sand content is reduced. The potting material should have a pH of 6. For seasonal flowers and vegetable crops, use elevated potting media beds with strip mulching.

5.2.2 High Humidity Chamber

This technique deals with the common problem of grafts or cuttings dying from desiccation when placed in soil for rooting by maintaining a humid environment surrounding the cuttings, preventing excessive evaporation. The cuttings/grafts are planted on a sand bed that is surrounded on all sides by a dome constructed of galvanized (GL) wire and wrapped in a transparent, colourless plastic film. The cuttings stay fresh and turgid for a long time. The dome must be shaded because direct sunshine will heat up the internal atmosphere and destroy the plants.

5.2.3 Drought Hardening

Plants raised in high relative humidity and shade often die due to transplanting shock when shifted to the fields. To prevent this, the plants are toughened by gradually adding outside dry air into the room.

This is accomplished by partially raising the plastic sheet on two opposing sides of the high humidity chamber, resulting in a small opening. Every day, the openings widen, allowing the entire film to be removed after around 8 days. This allows the plants to gradually adjust to the dry air. Such plants can be transplanted in the field, but as a precaution, transplantation will be done on a rainy or cloudy day.

5.2.4 Plastic Mulch

Mulch is a soil-covering layer that inhibits weed development, decreases water loss from the soil, and increases soil temperature. Mulching seed beds with opaque black plastic film reduces weed growth, increases soil temperature, and promotes early germination and seedling growth. When the seeds are evenly scattered, the bed is covered with a single, continuous piece of black plastic film. Holes are punched into the plastic to plant the seed and allow the seedlings to grow. If the seeds are planted in rows, add plastic strips between them.

5.2.5 Mini-greenhouse

Plants require carbon dioxide to produce food through photosynthesis. The greenhouse aids in giving additional carbon dioxide (CO2) to the plants, improving their rate of photosynthesis and so enhancing growth and output. This can be carried out by enclosing the plants in a box-shaped container made of bamboo and colourless translucent plastic, with a lid on top. The lid is closed after nightfall, allowing CO_2 from respiration to collect in the box. After sunrise, plants begin photosynthesis, and because there is more CO_2 around the plant, the rate of carbon assimilation increases. After a few hours, the lid is opened to prevent overheating. Alternatively, a plot or bed of plants can be covered with plastic film border held by bamboo pillars (about 120 cm tall), and CO2 will settle around the plants because it is heavier than air.

5.2.6 Compost

Composting includes soaking agricultural waste in water including cow dung, urea, and superphosphate. The agricultural trash is strewn on the ground in a thickness about 20 cm deep. The microbial culture is spread across the layer, which is subsequently coated with another layer of agro waste. The heap may reach a height of one meter. It is further protected with a plastic covering. The heap is stirred and covered once a month, depending on the ' state' of decomposition of the agricultural waste; overall decomposition time is 2-4 months.

5.2.7 Use of a Shade Net

Shade nets are effective for avoiding heat harm to young plants, as well as reducing plant water requirements by slowing transpiration. Shade nets are available in a variety of colours and densities.

5.2.8 Use of Supplementary Light

When the days get shorter, many plants go into winter hibernation. Additional light from tube lights after sunset creates long-day conditions, preventing plants from entering winter dormancy. Light towards the end of the day (photoperiod) promotes plant development. If light is filtered by a layer of green leaves, the plants grow tall but do not develop lateral branches. On the other hand, when exposed to fluorescent light (tube lights) placed on the ground, they sprout side branches and grow bushy. This is caused by the activation of phytochrome, a pigment found in all green plants that detects and responds to various types of light. To obtain the desired results, only about half an hour of light exposure is required right after.

5.2.9 Hormones

Several growth-promoting hormones are now commercially available. When used correctly, these compounds provide extraordinary outcomes in terms of shoot growth and roots. The appropriate combination and quantity should be determined in cooperation with the resource agency.

5.3 Modern Nursery Raising Techniques

Vegetable seedlings or nurseries can be grown in a number of containers, such as moulded trays and pots. Polystyrene and/or plastic trays are generally acknowledged as industry standards in many regions of the world. Plastic trays of uniform size with equal-sized cells cemented in Styrofoam are extensively used because they produce more consistent root zone temperature and moisture. In the United States, only Styrofoam flats are commonly preferred over plastic pro-trays. Cell morphologies vary within the seedling flats, with available shapes including inverted pyramid, circular, and hexagonal. While it is unknown if cell shape influences seedling field performance, cell size appears to have a definite effect because it varies by crop. The deeper celled trays generally, have a larger cell volume which makes available more water and nutrients to the transplants. Deeper cells, therefore, tend to support faster growth of transplants than shallow cells, which require frequent watering. To promote good root growth of the transplants in deep cell trays, water well and saturate the media all the way to the bottom of the plug. Deep and shallow celled trays should not be blended for a single crop or batch of transplants to ensure uniformity. Larger cell sizes often result in higher yields in the field, particularly for longer-cycle crops such as tomatoes and watermelons. Short-cycle vegetable crops, on the other hand, require smaller cells.

The normal cell size in the business is 1.0 inch by 1.0 inch (200 plants per plastic pro-tray). The economics and duration of the nurseries stay in the greenhouse influence the cell size of the tray for a specific crop. Vegetable nursery containers must have sufficient drainage and be capable of holding soilless media. They are also quite easy to handle.

Plastic trays: Plastic trays or pro-trays with varying cell sizes are often used to raise vegetable seedlings. In numerous European nations and Israel, two types of plastic pro-trays are primarily used for seedling cultivation: one with cells of 3.75 cm (1.5") in size and another with cavities measuring 2.5 cm (1.0"). The size of the cells is closely related to the type of crop to be seeded in the nursery trays. These trays aid in optimal germination, minimize mortality rates, ensure uniform and healthy seedling growth, and are easy to handle and store, as well as reliable and cost-effective for transportation. These plastic trays can be fixed in thermocol base trays with the same number and size of cells before being filled with media.

5.4 Advantages of Plug Tray Nursery Raising

i. Because there is no competition between plants, seedling homogeneity improves.

ii. Healthy seedlings can be developed in a short time.

iii. There is no possibility of soil-borne fungal or viral infection of the seedlings because the nursery is grown in soil-free sterilized media and insects cannot find their way under the protected conditions.

iv. Significantly lower seedling mortality when transplanted compared to the typical nursery rearing approach.

v. This nursery-raising approach facilitates early planting.

vi. It is useful for developing the nursery of sexually and asexually propagated vegetables, as well as ornamental crops.

vii. Managing insect pests and diseases in greenhouse/protected settings is quite simple, particularly for viral infections.

viii. Easy to move after packing for extended trips.

ix. Farmers can have the nursery ready at any time as needed.

5.5. Components of Transplants

5.5.1 Height Control

Height management is critical because elongated seedlings are more susceptible to biotic and abiotic stressors after transplantation. Heat, over-fertilization, over-watering, and low light conditions in a greenhouse or nursery can all produce excessive stem elongation. As a result, the height of transplants can be controlled by maintaining optimal temperature and light conditions, as well as controlling water and fertilizer dosages. Normally, 4-5°C DIF provides good control over seedling height. Seedling height can also be reduced by spraying growth retardants such as cycocel at a rate of 5-10 ppm, depending on crop and temperature, immediately after seedling emergence.

5.5.2 Controlling temperatures

Controlling temperatures is another method for controlling plant height. Cooler temperatures often slow down growth, while higher conditions accelerate it. Root and shoot growth increase linearly with temperature between 25°C and 35°C.

Another technique is to keep daytime temperatures below nighttime levels. Although many species respond positively to this type of therapy, some have chlorotic (yellow) leaves or stunted growth. Similarly, altering moisture, nutrients, and light can either inhibit or accelerate seedling growth. Chemical growth retardants are another option for controlling growth.

5.5.3 Pillowing and Control

Pillowing is defined as uneven growth caused by varied air circulation in the nursery greenhouse or building, as well as variances in watering patterns between cells within trays. In general, cells near the trays' periphery face drying conditions, resulting in stunted seedling growth when compared to transplants in the tray's middle. When larger plants begin to shade the growth media, the problem becomes even more serious. In contrast, shorter plants enable more evaporation since solar rays flow through them. As a result, individual flats are dome-shaped or "pillowed". This could be due to lose flat placement or abundant sunlight on one side of the trays, which results in a higher degree of drying.

5.5.4 Transplants Watering

Before initiating watering of vegetable seedlings, it is essential to know the quality of water to be used for the purpose.

5.5.5 Required Water Quality

The greenhouse fertilization approach may need to be adjusted depending on the pH, bicarbonate level, and nutrient content of the available water supply. If good quality water is not accessible, an alternative source should be sought. Water can fluctuate dramatically over time, so a comprehensive water analysis should be performed every year. This is especially true when water is pumped from shallow wells or areas with a high water table. The pH of the water used for plug transplants should be 5.5 to 6.5. Micronutrients are readily available to plants at the pH levels set in the nursery. Pond and well water is frequently alkaline (pH more than 7.0) and requires acid treatment to reduce pH.

5.5.6 Watering Frequency

The amount and frequency of watering differ according on cell size, growing media, greenhouse ventilation, crop, seedling age, and weather circumstances. Water thoroughly, to saturate the entire plug and encourage root growth from the bottom. If the plug is not completely irrigated, root growth is restricted to the top of the plug. Allow the plug to dry out before watering, but don't allow it wilt too much, as this will harm the transplants' root systems. Plug transplants should be fully irrigated in the morning, not in the late afternoon. If the plants remain damp overnight, fungal diseases may develop.

5.5.7 Irrigation

Watering is crucial for successful plug and transplant production. Water stress slows plants down and increases the likelihood of poor performance after they are planted outside.

Automatic or semi-automatic watering saves time, but it does not replace the need for personal touch-ups and watering on a regular basis. The plants will thrive, especially in plastic trays, if they are lifted off the ground to allow for good air circulation and water drainage. As a general rule, they should not be watered in the late afternoon to avoid becoming too damp at night. Watering schedules are also influenced by the size of plug cells.

One of the most common difficulties in greenhouses is overwatering. This not only inhibits plant development and health, but it also promotes the spread of diseases that thrive in wet settings.

Young plugs are especially vulnerable to overwatering, whereas older plugs are more prone to under watering. As a result, it is done as follows:

- ✓ Hand watering
- ✓ Stationary sprinklers
- ✓ Traveling boom sprinklers. Fogging
- ✓ Sub-irrigation

Hand watering and sub-irrigation are the best alternatives for small growers. The most significant disadvantage of hand watering is the high expense of labour. It's also less reliable than mechanical systems. Sub-irrigation addresses both of these difficulties; however, it may result in overwatering due to rapid saturation. Sub-irrigation works effectively for larger plugs. Plugs can leak fertilizer, sometimes excessively. Water per tray may be affected by air humidity rather than temperature or plant condition.

5.5.8 Transplant Fertigation

A well-grown transplant will have enough nutritional resources to establish quickly in a variety of field settings. Water-soluble fertilizers put into irrigation water are commonly used to fertilize vegetable transplants. Several fertilizer studies for transplant production differ in terms of nitrogen (N), phosphate (P2O5), potassium (K2O), and micronutrient content. Growers should use fertilizers that contain the majority of their nitrogen in the form of nitrate. Fertilizers with high quantities of urea should be avoided. The electrical conductivity of a 100 ppm solution in micromhos was determined using a conductivity meter and clean water.

Transplants should be watered as needed, and the nutrient solution content and application frequency should be adjusted to achieve the optimum level of growth. Fertilizer requirements vary according to cell size (bigger cells require less fertilizer) and nutrient charge of the growth media.

5.5.9 Deficiency in Seedlings

Plants exhibit nutrient insufficiency more frequently than toxicity. Most farmers avoid over-fertilizing for fear of "burning" the roots or stems. As a result, most fertilizer applications are postponed well beyond the time when the plant requires nutrients. Transplants that are low in phosphorus show purple pigmentation around the stem and underside of the leaves. Plants having insufficient nitrogen will have pale-green leaves. However, too much nitrogen causes white stems and dark-green leaves.

5.5.10 Hardening in Seedling

Hardening seedlings before transplanting into the main field is crucial for reducing transplant shock and boosting crop stand. Plants should be gradually hardened, or toughened, by exposing them to the anticipated growing conditions in the fields for at least a week before planting. Slowing their growth rate enables them to withstand cold, dry winds, a lack of water, and high temperatures. Withholding or using restricted amounts of water are the most effective ways to harden a transplant. Seedlings generated in larger cells have been proven to produce higher and earlier yields than smaller cells, but the overall yield remains same. Generally, seedlings of any plant are ready for transplanting 28-32 days after sowing in plastic pro-trays.

5.6 Uprooting /digging

To avoid the damage to the roots, it is advisable to irrigate nursery, 3-4 days before the actual date of lifting the plants. The lifting of (evergreen spp.) saplings should however be avoided in case if there is heavy rain in the rainy season because earth ball does not form properly if soil is too wet. To achieve high rate of yield survival of evergreen tropical or subtropical plants, these should be uprooted with a ball of earth. Deciduous plants can be lifted bare rooted.

5.7 Labeling and Packaging of Nursery Material

Plug plants are packed in corrugated card (CC) with styropor lining, but when CC containers are not practicable, and the packing is available in two carton sizes. Depending on plant height, the small carton can carry two or three trays. The huge carton carries five or six trays.

Small: H x L x W = 215 x 585 x 340 mm
Large: H x L x W = 410 x 585 x 340 mm

Copper-treated plug flats improved root development and flowering in bedding plants.

5.8 Scheduling for Holding Plugs

Transplants are usually ready to plant outside before the weather allows. This has prompted research into the effects of storing or holding plugs at low temperatures. Controlling humidity, fertility, wetness, and light is essential when holding plugs.

Lower humidity helps to inhibit sickness, but it can also cause water stress. Plugs given too much nitrogen do not store well. Michigan State University found that light above 5 foot-candles was good for stored plugs.

Check Your Progress Exercise 1

Note : a) Space is given below for answers.

1) What are major components of transplant need to be considered?

....

2) What are the means of controlling disease of transplants in nursery?

....

3) Discuss components of transplants.

....

Summary

In this unit, we examined new significant knowledge on plant propagation and nursery management to stay up with the changing times. Basic and up-to-date information about plant propagation is presented. Green houses, soilless media, seed production, processes for propagating vegetable and flower seedlings, transplant disease prevention, hardening seedlings before transplantation in the field, and seedling packaging have all received particular emphasis.

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Unit 6: Establishment of Nursery II

Unit Structure

6.0 Learning Objectives

After going through this unit you will be able to:

- Understand about the Planting layout
- Understand the criteria of site selection
- Formulate the planning and nursery layout.
- Identify the facilities required to establish a nursery.

6.1 Introduction

In a nursery, trees, shrubs, seedlings, and other plant materials are raised and cared for until they are planted in a permanent location. Establishing a nursery is a long-term and permanent venture. Any fault made at the beginning cannot be changed later.

Thus, a healthy crop is the foundation on the availability of high-quality planting material. The present unit deal with the some important component while establishing a nursery i.e., legal title of land, survey, site selection; planting layout, season or time of planting, planting pattern, spacing, enrichment planting.

6.2 Legal title of land, survey

Enough ground should be available to raise the required number of seedlings, plus additional space if needed for growth. It is advisable to conduct legal research to determine the land's true ownership.

Generally, nurseries are establishment in the forest land, van panchayat land, as well as in the private land. The forest department has the stakes on the nurseries established in forest land and maintained by the forest department. The vanpanchayat oversees and maintains the nursery in vanpanchayat territory. Similarly, in private land the land owner have the stakes of nursery. However, the private nursery can be run only after registration and getting the license from the line department. The first step in a establishing the nursery is to carry out a survey of an area and preparation of treatment map. Following points should be kept in mind while establishing a nursery:

(i) The nursery should be situated in the key producing areas as much as feasible.

(ii) There should be no soil-borne infections and the soil should be deep, fertile, and well-drained.

(iii) A sufficient supply of sweet water should be available in the area.

(iv) The climate must be suitable for the plants to be multiplied or propagated.

(v) The location needs to be easily accessible and well-connected via various communication channels.

(vi) To manage various tasks, there should be an adequate availability of labour, budders, and grafters.

(vii) All necessary supplies, including lanolin paste, growth regulators, grafting waxes, fertilizers, and insecticides, should be easily accessible.

(viii) Enough space should be set out for various propagation structures, such as net homes and glasshouses.

(ix) In order to supply parent material (mother plants) for propagation, the nursery should have sufficient resources.

6.3 Nursery Site Selection

Selecting a suitable nursery location is the most crucial choice influencing the effective production of high-quality plants. Important factors to take into account when choosing a nursery area are: The chosen region should have adequate drainage, be free of water logging, have enough sunlight, have the nursery close to a water source for convenient irrigation, and be well-protected from both domestic and wild animals.

Each nursery's ability to succeed is primarily dependent on the type of soil it has and the quantity and quality of water it receives. Soil and water analyses must be completed prior to nursery site selection, as most fruit and ornamental plants are sensitive to salinity and alkalinity. Good fertility, enough water-holding capacity, light to medium texture, and adequate drainage are all desirable qualities in soil. For any nursery, soil with a pH of 5.5 to 6.5 is ideal. The salinity in soil and irrigation water causes salt damage, which can cause nutritional shortages, marginal leaf browning, and in severe cases, plant death, particularly during the summer. Consequently, the success of a commercial nursery greatly depends on the careful selection of soil and a high-quality irrigation water supply.

A nursery setup requires careful consideration of the following technical factors:

(i). Source of Water: A sufficient and dependable water supply is necessary. In order to have good irrigation facilities it should be located close to, or bit below, a source of a sufficient amount of water. The water source should be closer to the nursery location and at a higher elevation. There should always be water available.

(ii). Suitable Soil Availability: The nursery's actual soil is not important for growing seedlings in polythene bags or tubes. The nursery needs to have easy access to a good supply of soil, ideally forest topsoil and sand. Because of their poor drainage and aeration, and risk of cracking in the summer, clayey soils should not be chosen. The presence of symbiotic organisms, such as Rhizobium and Mycorrhiza, in soil is necessary for most trees to grow to their full potential. These symbionts aid in the nourishment of the trees' roots. In most situations, artificial inoculation is required, but certain organisms are present naturally.

(iii). **Access to Nursery:** The nursery should be situated as close to the centre of the planting area as feasible. To ensure frequent and close observation, it should ideally be close to the residence area. To make it easier to transfer seedlings, the nursery should be close to the plantation site, and the access road should be passable throughout the year.

(iv). **Topography:** A well-planned and laid-out slope can easily impress clients by facilitating a smooth irrigation water flow and providing a spectacular panoramic view. The area needed for the nursery is determined by the types of plants to be grown or multiplied as well as the goals of planting materials for various plant crops. At high elevations, a south-facing slope is preferred for hill nurseries because it is warmer, whereas at low elevations, a north-facing slope is preferred. That slope is appropriate since it is sufficiently steep to enable adequate drainage. Avoid completely flat terrain as it would probably get flooded during the rainy season. More steep slopes should be avoided as it may be difficult to create a nursery bed and path on either side to provide access to the beds.

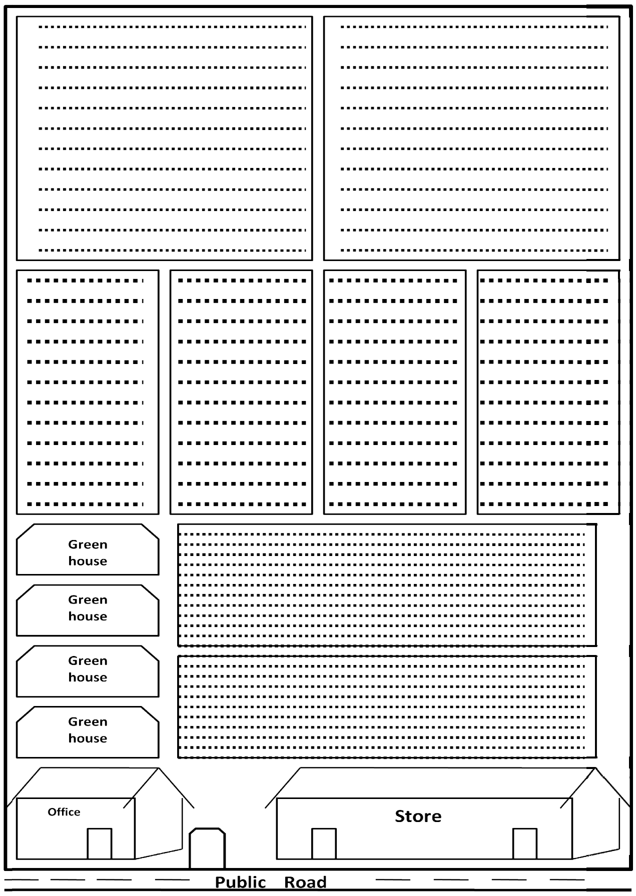
(v). **Flooding, High Winds, and Frost Exposure:** Locations where frost damage is particularly likely should be avoided at high altitudes. Similarly avoid those locations which are vulnerable to high winds, have a risk of floods, or have landslides.

(vi). **Labour:** Labour should be easily accessible, ideally close to a hamlet so that workers won't have to travel far to get to work.

6.4 Planning and Layout

The nursery's layout is one of its most important operations. In order to improve the nursery's aesthetic appeal and to ensure proper plant development and the required number of plants per unit space, the plants have been carefully placed in the plot.

The nursery should be set up with consideration for the ideal "propagation environment," hence everything about it should be designed with it in mind. Container nurseries should always be arranged so that the propagation zones receive as much sunlight as possible. Compounds for open growth should be positioned to maximize sunshine exposure while providing enough wind protection. Large trees, structures, or other impediments that can provide shade for the most of the day should not be placed close to them. A developing complex ought to be situated at least 2.5 times the height of the closest object to the south, east, and west as a general rule. Shelterbelts placed correctly may reduce the negative impacts of wind. In addition to providing protection from hazardous storms, a well-designed wind barrier or tree shelterbelt may significantly decrease heat losses of propagation structures and irrigation wind drift in shelter houses or open growth compounds. The most crucial phases in growing seedlings in a nursery include choosing an appropriate location for the seedbeds, planting seeds, tending to the seedbeds, caring for the seedlings, and finally moving the seedlings.



Nursery Layout

Although it may appear simple in theory, growing plants in nurseries is a challenging task that can only be completed successfully and efficiently with some experience. Since there are many different kinds and components of nurseries, one must have a basic understanding of the plants that will be cultivated, making it a specialized employment.

In the same way, one should be adequately familiar with the cultural needs of the plants that will be grown in the nursery. Typically, seeds are sown three to four times deeper than their actual size. In light soils, you can sow a little bit deeper than in heavy soils. Many factors affect the selling of seeds, but the species, purpose, and spacing are the main determinants.

Following the location of the nursery's establishment, planning may be carried out with the assistance of a nurseryman or professional horticulturist. In addition to carrying out various nursery operations most effectively and economically, doing so can significantly lower the costs associated with establishment, production, and marketing.

The following elements need to be considered and accommodations made for while designing and arranging the nursery.

6.4.1 Fencing

In order to keep animals away of the nursery and to discourage theft, a strong fence with barbed wire on top needs to be built around the nursery before establishment. Furthermore to strengthen the fence, put in a live hedge with spiky fruit plants or bushes. Through the sale of fruits and seedlings, this increases the aesthetic appeal of bearing as well as generates extra revenue.

6.4.2 Making of Roads and Paths

In addition to adding aesthetic value, well-planned internal roads and pathways will facilitate simple, cost-effective nursery operations. One way to do this would be to create distinct areas and blocks within the nursery. However, space shouldn't be wasted by building roads and trails which are not necessary at all. A point of attraction inside the nursery area should be accessible to clients via each road and pathway.

6.4.3 Progeny Block

A progeny block is a group of plants kept in a nursery in accordance with the requirements, where mother plants of superior varieties that are true to type are kept. An immaculate progeny block, mother plant block, or scion block containing varieties that are in high demand should be present in the nursery. The best places to get grafts, layers, rooted cuttings, seedlings, or original breeders/research agencies from where they are released are or should be renowned nurseries. It is important to keep in mind that the first selection of mother plants or progeny plants for additional multiplication is vital to the success of any nursery. The nursery's status will be damaged by any errors done in this area. Because fresh scion material is available all season long within the nursery and there is no waiting period between the division of the scion and the graft age, a well-managed progeny block or mother plants block will not only encourage confidence in the customers but also decrease production expenses and increase the success rate of grafting, budding, and layering.

6.4.4 Generators, pipelines, wells, etc

Fruit and decorative nursery plants, which are planted in poly-bags or pots with little potting mixture, need a lot of water for establishment, growth, and development. Thus, the seedlings, seed beds, containers, etc. should be appropriately watered. It is important to have a way to conserve enough water to irrigate nursery plants in places with limited water yields and frequent interruptions in electricity. A backup source of electricity, such as a generator, must be kept up to date in places where interruptions in electricity are common to ensure the smooth operation of the pump-set. An efficient PVC pipeline system may significantly reduce the issue of water scarcity, which is a constraint in many regions, especially in the winter. Regarding pipeline layout, this may be a good time to engage an expert agricultural engineer. This would make it easier to distribute irrigation water to the different nursery components in an economical and efficient manner.

6.4.5 Office/Combined Store

The nursery cannot be managed effectively without an office/stores combination. It is possible to locate the office building in a way that allows for improved nursery monitoring and makes it possible for the nursery employees to welcome and assist clients. The office block could be furnished with eye-catching pictures of decorative and fruit kinds grown in the nursery along with information about each one. Poly bags, tools, packing supplies, labels, fertilizer, insecticides, and other items need to be kept in a storage space of an appropriate size.

6.4.6 Seed Beds

To raise the seedlings and rootstocks in a nursery, this component is necessary. Considering their regular watering and irrigation needs, they should be placed close to a reliable source of water. Beds should be prepared that are one meter wide or any suitable length. Between each bed, there must be a 60-centimeter working space. Which makes it easier to water, spray, weed, sow seeds, and lift seedlings. Convenient placement of irrigation channels is required. Or else the beds could be watered by a sprinkler system of irrigation. Entire seedling growth along with regular germination is facilitated by sprinkler irrigation.

6.4.7 Nursery Beds /Poly bag

When compared to nursery beds, growing seedlings or rootstocks in poly bags takes up more room, but after transplantation, the death rate of the seedlings or rootstocks is significantly lower. Furthermore, growing seedlings or rootstocks in poly bags allows for the maintenance of consistency in their growth. In order to accommodate 500 grafts or layers in each bed, the nursery bed area should also include a feature that allows the grafted plants to be kept in trenches that are 30 cm deep and one meter wide. An alternative arrangement for the grafts and layers would be to set them on the ground in one-meter-wide beds with a 60-centimeter working space between each bed. These beds can be irrigated by above micro sprinklers or by a rose attached to a flexible hosepipe.

6.4.8 Potting Mixture and Potting Yard

A high-quality potting mixture is essential for better nursery plant performance. Potting mixes can be made using a variety of ingredients and amounts, including well-rotted FYM, oil cakes, vermin-compost, leaf mould, and fertile red soil. By adding enough super phosphate to the potting mixture prior to time, it will decompose and solubilize more easily. The potting mixture can be stored close to the area used for potting and pocketing. Building a potting garden that is the right size makes it easier to perform grafting/budding or potting of seedlings, even on rainy days.

6.5 Planting pattern

After taking consideration of the land's slope, the intended use of the area, convenience, etc., the planting strategy to be used is chosen. In general, the six planting strategies are advised. Learners, an overview is provided here; however, unit number 14 will provide more insight regarding the planting pattern.

6.5.1 Square system

This system is frequently used and regarded as the most straightforward of all. The area of land is divided into squares using this method, and plants are placed in straight rows at right angles at each of the square's four corners.

6.5.2 Rectangular system

Instead of using squares to divide the plot, this method uses rectangles, and plants are placed in straight rows at right angles to each other at the four corners of each rectangle. The main difference is that this approach allows for more plants to be planted in each row while maintaining more space between rows.

6.5.3 Triangular system

The plot is divided into squares for this scheme, and the planting is done similarly, with alternating rows planted midway through. Other than offering more open space for trees and intercrops, this layout offers no particular advantages over the square arrangement. In addition to being a difficult layout, this system makes it harder to cultivate the plots.

6.5.4 Hexagonal system

Six trees form a hexagon with the seventh tree in its core when using this approach, with the plants placed at the corners of an equilateral triangle. In areas with high land costs, high fertility, and plentiful irrigation water supplies, this technique is typically used.

6.5.5 Quincunx system

The only difference between this method of planting fruit trees and the square method is the addition of a fifth tree to the centre of each square. Consequently, the number of trees in a unit area nearly doubles compared to the square arrangement.

6.5.6 Contour system

Usually, it is practiced on hills with steep slopes. It works especially well on land with uneven terrain, where erosion is more likely and irrigation is more challenging. This system's primary goals are to reduce soil erosion and retain soil moisture so that the slope is suitable for growth.

6.6 Enrichment planting

A key method in the restoration of forests is the growth of enrichment crops. According to the definition, it is "the introduction of economically important species into degraded forests without eliminating valuable species that are already present at that specific site." Enhancing the density of target species in the secondary forest is a popular application for it. The term "enrichment plantation" refers to the beautification of an area. Making rich or fertilizing are further meanings of the word enrichment.

It can be effectively applied to raise secondary forests' value and stop them from being converted to other purposes. Therefore, in the context of the present worldwide attempts to prevent deforestation in developing countries, enrichment planting and reducing deforestation could be key land use strategies. Planting exotic and native species in wide gaps is known as enrichment planting. Before planting, the plants can be gathered from the forest floor seedlings or produced in nurseries.

6.7 Nurse crops

Nurse crops are grown primarily for use in the raising of a less hardy species. Usually, they are eliminated early on after fulfilling the purpose for which they were created. The primary crop is usually protected by the nursing crops from the sun, frost, and other biotic and environmental factors. The primary purpose of raising nurse crops is to support shade-bearing species, which are initially vulnerable to cold. Some species are shade-tolerant. Some of these species are less shade-tolerant than others, but they are all so vulnerable that they are killed by direct sunshine. For example, some firs have a broad, open forest on the slope. This is because seedlings are initially extremely sensitive, but as they grow older, they become resilient and light-sensitive. For example the nurse crop of *Abies pindrow,* is *Pinus wallichiana* (blue pine). Walnut and Poplar can also serve the same purpose.

Summary

In this unit, you have studied about the purpose of survey, site selection, planting layout, season or time of planting, planting pattern, enrichment planting, designing etc. You have also learnt about different types of key points of the establishment of the nursery, their construction method and raising seedling. We have also discussed about the need of nursery, planning and layout of nurseries. We have also learned about the enrichment of the planting and the nurse crops.

Check Your Progress

1. Discuss the importance of nursery. Why not one can directly raise seedlings in an open field environment?
2. Discuss the pre-requisites for establishment of a nursery.
3. What do you mean by the nurse crops?
4. Describe the Planning and Layout of nursery in detail.
5. What are nursery beds? Describe.

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Unit 7: Maintenance of Nursery

Unit Structure

7.0 Learning Objectives

On completion of this unit you will be able to understand:

- About fencing and its types.
- About the soil fertility
- About the plant nutrients
- Watering, weeding and nutrients management in nursery
- Use of hormones and growth regulators in nursery

7.1 Introduction

Learners, in the previous units you have learnt about the nursery, its importance, establishment, types of nursery, nursery tools etc. Now you have got the basic understanding of nursery. Since plants grown in a nursery, care must be taken in nourishing them in order to ensure their growth, development and better production (Quality Planting Martial). In order to understand this the present unit deal with the maintenance of the nursery which covers about the fencings, kinds of fencing, importance of fencing in nursery, soil fertility, plant nutrients, watering, weeding, use of hormones and growth regulators etc.

7.2 Fencing and types of fencing

The nursery need to be protected from external factors such harm caused by domestic and wild animals feeding on them. Fencing is necessary for the nursery for this reason, and the following improvements can also be implemented in the nursery:

- Barbed wire fencing measuring 1.5 metres in height is used for a temporary nursery.
- Constructing a fence or stone wall to keep animals out of the permanent nursery.
- Planting wind barriers and shelter belts to offer cover in arid regions.
- Putting spiky shrubs on the bed will protect it from birds.

The following kinds of fencing are effective for use as protection:

(a) Live-Hedge Fencing: The live hedge-fencing gets more flexible and dense with time. It is best to choose a spiky species. By cuttings, it ought to be able to arise. Better coppicing power is also expected. For live-hedge fencing, the following plants are appropriate:

Euphorbia spp, Agave sislana, Agave americana, Jatropha curcas, Acacia nilotica, Acacia tortilis, Acacia catechu, Prosopis juliflora, Ipomaea, etc. Similarly, brushwood cuttings can be temporarily utilised as a fence material.

(b) Wire Fencing: There are three types of wire fencing, which are as follows:

(i) Barbed wire fencing: This works best, although it is really expensive. On angle iron or cement posts, four to six strands of horizontally knitted galvanized iron barbed wire are utilized in a crosshatch pattern. U-nails are used to secure the barbed wire strands.

(ii) Plane wire fencing: Sheep and goats cannot be contained by the wooden posts and wire fencing made of plane wire, which works well against larger animals. Bamboo stakes can also be used in replacement of wooden posts (poles or sawn timber). Bamboo is utilised for both vertical and crisscross stakes and posts, as well as for attaching wire and posts. Mud or preservatives such as arsenic-copper sulphate (ASCU) should be applied to the wood or bamboo that is to be utilized.

(iii) Woven wire fencing: Wooden, cement, or angle iron pillars are used to hold woven wire net. Even little animals are unable to get through the woven wire fencing. It's hard for the pigs, rabbits, deers, swine, and even rodents to find their way through. Plants that are vulnerable and highly prized should be protected with woven wire fencing. This type of fencing is also known as porcupine or game proof fencing. It is also possible to utilise the woven wire in addition to the barbed wire. The upper section of the fencing is tied with barbed wire.

(c) Trench cum Mound (TCM) Fencing: There is no fencing material needed for this kind of fencing. The entire area is surrounded by the trench. The mound is composed of excavated soil. Its dimensions are 1 m deep, 1.90 m broad at the top, and 0.60 m wide at the bottom. While there is 1250 m^3 of earth work required per km, the TCM slope along the afforested region would be nearly vertical. A 20 hectare plot with 500 m x 400 m sides would have 1800 m as its perimeter. TCM would require 112.5 m^3 of ground work and an average length of 90 m per acre. On the outside of the TCM's inner wall, the top fertile soil layer can be built, and next to it, the lower infertile layer may be pushed inward. The TCM gap is filled in by rubble or a high enough stone walls to keep animals out of the area when digging is not feasible due to the hard, stony substratum. Frequent maintenance and repairs of the TCM should receive regular attention. In areas with exceptionally high cow populations and high grazing pressure, there would be total protection against biotic interference and cattle population.

(d) Rubble Wall Fencing: Where stones are widely and reasonably available, stone walls or rubble wall fencing are constructed. The 1.25 m high and 1 m thick wall is composed of chunks of stone or rubble. Cattle occasionally manage to get through the barricade of rubble. Strong enough woven iron-wire netting should be used to tie off these rubbles.

(e) Stone Walling: In western Rajasthan, where stones are easily accessible, this type of stone plank fencing is popular. Nearly one-foot-wide and 1.5–2.5-meter-tall stones are set into the earth along the edge. Although quite strong, this kind of fencing requires frequent maintenance.

(f) Electric Fencing: This is uncommon in our nation and there are a number of reasons why this is uncommon. Although several national parks have tried this kind of barrier, the locals do not find it acceptable. The type of issue at hand, the depth of the soil, and the fencing project budget should all be taken into consideration when selecting a fence.

(g) Combined Fencing: This kind of fencing is created by merging together two or more fence varieties. e.g. (i) Barbed wire and TCM (ii) Stone and live hedge (iii) live hedge and barbed wire (iv) barbed wire, and woven wire (v) dwarf pakka wall, barbed wire and live hedge and so on.

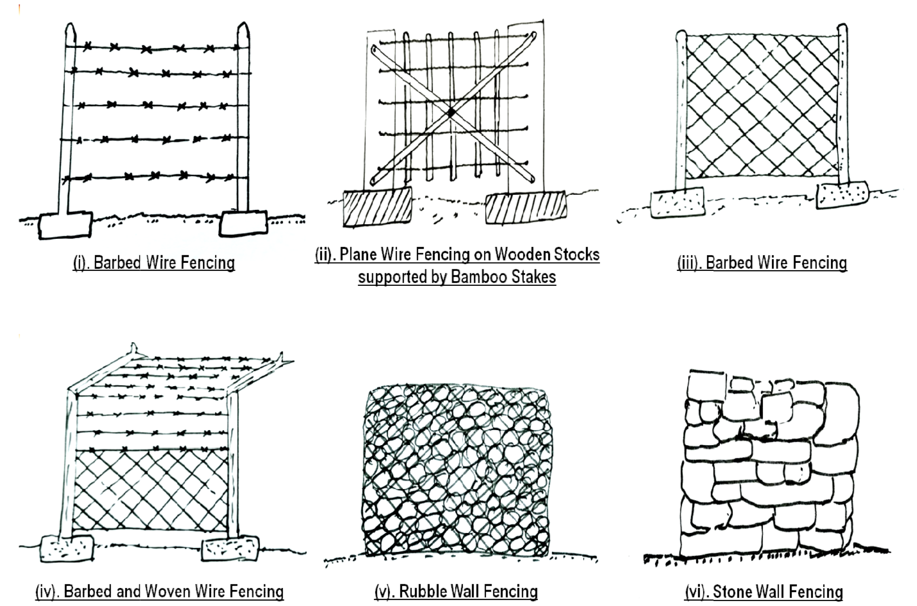

Fig. 2: Different kinds of fencing

7.3 Soil fertility

The ability of the soil to support plant growth i.e., to give plants a home and produce high-quality crops over time" is referred to as soil fertility. It also refers to the soil capacity to provide crop and plant nutrients in the proper amounts and forms over an extended length of time. The characteristics of fertile soil are as follows:

- The capacity to provide necessary supplies of water and nutrients to plants in order to support their development and regeneration.
- The absence of harmful compounds that might hamper on plant growth, such as $Fe2^{+}$, which causes nutrient toxicity.

In most cases, the following characteristics increase soil fertility:

- enough soil depth to support healthy root development and retention of water;

- Appropriate internal drainage that permits enough aeration for ideal root development (while many plants, like rice can tolerate water logging);
- There is enough soil organic matter in the topsoil, or horizon O, to support a strong soil structure and soil moisture holding;
- The pH range of 5.5 to 6.5 is ideal for most plants (while some are more tolerant of or prefer more acidic or alkaline environments).
- Sufficient amounts of necessary plant nutrients in forms that are accessible to plants;
- A variety of microorganisms which stimulate plant growth are present.

7.4 Plant Nutrients

There are 16 elements which are necessary for healthy plant growth. 95% of plant solids are made up of nitrogen found in the soil, hydrogen, and oxygen derived from air and water, and carbon. Despite the fact that 78% of the atmosphere is nitrogen, plants cannot use it. But some bacteria can fix nitrogen from the air so that plants can use it. These bacteria grow in nodules on the roots of legumes. Phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, manganese, zinc, boron, chlorine, and molybdenum are the remaining 12 important elements. The soil is the source of these elements. All of these elements—aside from phosphorus, potassium, calcium, and magnesium—are often present in sufficient amounts in the soil to support crop growth.

Table 1. Macronutrient Elements

Element	Symbol	Chemical form most frequently absorbed
Carbon	C	-
Hydrogen	H	-
Oxygen	O	O_2
Nitrogen	N	NO_3^- NH_4^+
Potassium	K	K^+
Calcium	Ca	Ca^{++}
Phosphorus	P	$H_2PO_4^-$ HPO_4^+
Magnesium	Mg	Mg^{++}
Sulfur	S	SO_4^+

Table 2. Micronutrient Elements

Element	Symbol	Chemical form most frequently absorbed
Molybdenum	Mo	MoO_4^{2-}

Copper	Cu	Cu^{+} Cu^{++}
Zinc	Zn	Zn^{++}
Manganese	Mn	Mn^{++}
Iron	Fe	Fe^{++} Fe^{+++}
Boron	B	BO_3^- $B_4O_7^-$
Chlorine	Cl	Cl^-

As listed in Tables 1 and 2 there are sixteen elements that are necessary for plant growth. Oxygen, hydrogen, and carbon are derived from water or air. As plants need a comparatively high amount of nitrogen, phosphorous, and potassium for optimal growth, these elements are referred to as fertilizer macronutrients. Secondary macronutrients like calcium, magnesium, and sulphur are typically provided inadvertently together with other minerals, such lime, or they are present in adequate amounts. Even though they are needed in lesser amounts, the remaining seven nutrients—known as micronutrients—are equally essential. Plants will show indications of a nutritional shortage if any of these components are low. Nutrient toxicity may be increased by excessive amounts.

7.5 Watering, Weeding and Nutrient Management in Nursery

Water is an essential component in seed germination and seedling growth, but too much water can be just as hazardous as too little. The size of the nursery, the type of soil, the species, the quantity of seedlings, and the watering technique all affect how much water is needed. As the sandy soils in dry regions are not very good at retaining water, more water is required in these nurseries. During the dry season, an approximate hectare-sized nursery would need 60,000 liters of water each day. The ability to retain water for a minimum of three days must ensure a steady and dependable supply of water, preventing seedlings from drying out. The quality of the water utilized for irrigation must also be assured. Water with a pH of 7 or below is ideal for "damping off" fungal assaults, but normal pH water is the best choice. Watering should ideally be done in the morning and avoided at midday because the sun will cause significant evaporation. Growth regression and mild to severe yellowing are the obvious signs of overwatering. The watering mechanism may not always distribute water evenly across a big cluster of seedlings, resulting in "wave" formations. This condition should not be confused with clusters of plants that grow slowly, which is usually the result of a nutrient shortage. One of the initial indicators of under watering is wilting. For very small nurseries, the obvious way to water them is by hand using cans with rose spray or backpack mist nozzles. Overhead sprinkler irrigation is the best technology for large nurseries while it is the most uniform way to apply water and is very easy to operate.

Any plants that are in the cultivation area but are not in our interest are considered weeds. Because weeds typically develop more strongly and quickly than seedlings, they constrain the growth of seedlings by competing with them for nutrients, water, and light. Grass and other dicotyledonous plants that develop from a root stock are the most problematic. It is necessary to remove the entire plant because if a weed of this type is chopped off at the ground, it will grow back from the carbohydrates stored in its root tissue. Weeds can be eradicated before transplanting by watering the soil used for planting and the pre-filled containers beforehand, as it is more challenging to remove them once they have infected seedlings growing in containers and transplant beds.

For this reason, if weed-free soil for potting is not available, containers should be filled up to four weeks before transplanting or direct sowing operations. Weed seeds that would normally be carried in by wind are kept out of the nursery by a dense hedge surrounding it. Proper seedling development requires the presence of sixteen plant food nutrients. Despite the fact that each is equally essential to the plant, the levels needed for each vary significantly. In nurseries, the most commonly needed nutrients are nitrogen, phosphorus, and potassium, which are classified as primary or macronutrients. Although seedlings would show deficiency symptoms in the event of a nutrient shortage, the appropriate fertilizer should be applied as needed.

In nurseries, FYM and compost are usually used for general nutrient support when the available soils are either excessively heavy or sandy and of poor quality. It enhances the soil's ability to retain water, helps to create a healthy soil structure, and supplies plants nutrition. It significantly lessens the requirement for chemical fertilizers and decreases those that are used when combined in modest amounts, increasing the amount of usable fertilizer that is available. Thus, it is a cost-effective method of applying readily available chemical fertilizers and, like humus, is a natural fertilizer in and of itself.

When seedlings are placed in unprocessed compost, their leaves generally become yellow. This is because the plant cannot get all the nutrients it requires, and the immature compost keeps absorbing all the accessible nitrogen. A nursery mixture supplemented with well-decomposed manure will guarantee the generation of healthy and high-quality seedlings. Phosphorous must be supplied to promote rhizome growth, and urea management will result in good vegetative/foliar growth of seedlings. In the meantime, it is advised to use bio-fertilizers to promote seedling growth, such as vermin-compost, VAM, and *Azatobactor, Azospirillum*, and Phosphobacteria (5 to 10 g) per container-raised seedling.

7.6 Use of Hormones and Plant Growth Regulators in Nursery

For growth and development, plants need light, water, oxygen, minerals, and other nutrients. In addition to these external demands, plants are dependent on certain chemical molecules for indicating, regulation, and growth control. Certain hormones or stimulants are utilized in nurseries to help them produce as much as is wanted. While people apply plant growth regulators to plants, plants naturally create hormones. Growth regulators and plant hormones are substances that influence: Flowering; Aging; Root growth; Distortion and killing of organs; Prevention or promotion of stem elongation; Color enhancement of fruit; Prevention of leafing, leaf fall or both; Many other conditions

Significant alterations in growth are observed at very low concentrations of these compounds. compared to naturally existing plant hormones, plant growth regulators might be synthetic substances (like IBA and Cycocel) or naturally occurring hormones derived from plant tissue (like IAA).

Table 3. Uses/Effects of compounds on plant growth

Compound	Effect/Use
Gibberellic acid (GA)	Stimulates cell division and elongation, breaks dormancy, speeds germination
Ethylene gas (CH_2)	Ripening agent; stimulates leaf and fruit abscission
Indoleacetic acid (IAA)	Stimulates apical dominance, rooting, and leaf abscission
Indolebutyric acid (IBA)	Stimulates root growth
Naphthalene acetic acid (NAA)	Stimulates root growth, slows respiration (used as a dip on holly)
Growth retardants (Alar, B-9, Cycocel, Arest)	Prevent stem elongation in selected crops (e.g., chrysanthemums, poinsettias, and lilies)
Herbicides (2,4-D, etc.)	Distorts plant growth; selective and nonselective materials used for killing unwanted plants

When these compounds are applied, their concentrations are often expressed in parts per million (ppm) or, in rare circumstances, parts per billion (ppb). Most frequently, a liquid drip or spray application of these growth-regulating agents is made to the soil surrounding a plant's base or to the foliage. They may need to be reapplied in order to get the desired result because their effects are usually temporary.

.Groups of plant-growth-regulating compounds

Plant growth-regulating chemicals can be divided into five groups: auxin, gibberellin (GA), cytokinin, ethylene, and abscisic acid (ABA). Each group primarily consists of both synthetic and naturally occurring hormones.

(i) Auxin: Auxin triggers a variety of reactions in plants:

- Phototropism or bending towards a light source.
- Geotropism or the downward growth of roots in accordance to gravity.
- Encouragement of apical dominance, which is the ability of an apical bud to secrete hormones that inhibit the growth of buds on the stem below it.
- The formation of flowers.
- Fruit setting and growth.
- The emergence of accidental roots.

The majority of rooting chemicals, in which cuttings are dipped during vegetative propagation, contain auxin as their active element.

(ii) Gibberellins: Gibberellins break seed dormancy, promote growth and multiplication of cells, and accelerate germination. Certain species' seeds are challenging to germinate, but you can try soaking them in a GA solution to help.

(iii) Cytokinins: Cytokinins are present in both plants and mammals, in contrast to other hormones. They frequently contain them in the sterile conditions used to grow plants from tissue culture because they promote cell division. The tissue culture explants, or small plant portion, will sprout many shoots if the medium's mixture of growth-regulating chemicals is high in cytokinins and low in auxins. However, the explants will generate more roots if the mix has a high auxin to cytokinin ratio. Moreover, cytokinins are utilised to avoid senescence, or the ageing process.

(iv) **Ethylene:** The only way that ethylene may be discovered is as a gas. Senescence is encouraged, ripening is induced, and leaves droop and drop Ethylene is frequently produced in larger amounts within plant cells near the end of its life, and plants frequently boost its synthesis in response to stress. A certain amount of how leaves fall from trees is due to the increased ethylene in leaf tissue in the fall. Fruit (like green bananas) is also ripened by ethylene.

(v) **Abscisic acid:** A common inhibitor of plant growth is Abscisic Acid (ABA). It produces abscission of leaves, fruits, and flowers; it closes stomata; it induces dormancy and stops seeds from developing. Stomatal closure during drought stress is likely influenced by high ABA concentrations in guard cells.

7.7 Maintenance of Nursery Records

It is necessary to keep up-to-date records of all purchases (seed, chemicals, media, etc.); data observation (sowing, germination dates and germination percentage, growth, etc.); labour engagement and attendance; sales; pest and disease outbreaks; permanent and temporary stocks (including species-specific seedling stocks); and movement registers. Multiple records detailing expenses and earnings are kept in separate books, such as purchase books, sales books, ledgers, cash books, dispatch registers, etc. For the following reasons, keeping books of accounts is advised:

- They offer up-to-date data on nursery business and planning guidelines.
- They assist in analysing the effectiveness of the nursery activities.

Summary

- The nursery need to be protected from external factors such harm caused by domestic and wild animals feeding on them. Fencing is necessary for the nursery for this purpose.
- The ability of the soil to support plant growth i.e., to give plants a home and produce high-quality crops over time” is referred to as soil fertility. It also refers to the soil capacity to provide crop and plant nutrients in the proper amounts and forms over an extended length of time.
- There are 16 elements which are necessary for healthy plant growth. 95% of plant solids are made up of nitrogen found in the soil, hydrogen, and oxygen derived

from air and water, and carbon. Despite the fact that 78% of the atmosphere is nitrogen, plants cannot use it. But some bacteria can fix nitrogen from the air so that plants can use it. These bacteria grow in nodules on the roots of legumes. Phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, manganese, zinc, boron, chlorine, and molybdenum are the remaining 12 important elements.

- Water is an essential component in seed germination and seedling growth, but too much water can be just as hazardous as too little. The size of the nursery, the type of soil, the species, the quantity of seedlings, and the watering technique all affect how much water is needed. As the sandy soils in dry regions are not very good at retaining water, more water is required in these nurseries. During the dry season, an approximate hectare-sized nursery would need 60,000 litres of water each day. The ability to retain water for a minimum of three days must ensure a steady and dependable supply of water, preventing seedlings from drying out.
- Any plants that are in the cultivation area but are not in our interest are considered weeds. Because weeds typically develop more strongly and quickly than seedlings, they constrain the growth of seedlings by competing with them for nutrients, water, and light. Grass and other dicotyledonous plants that develop from a root stock are the most problematic. It is necessary to remove the entire plant because if a weed of this type is chopped off at the ground, it will grow back from the carbohydrates stored in its root tissue.
- For growth and development, plants need light, water, oxygen, minerals, and other nutrients. In addition to these external demands, plants are dependent on certain chemical molecules for indicating, regulation, and growth control. Certain hormones or stimulants are utilized in nurseries to help them produce as much as is wanted. While people apply plant growth regulators to plants, plants naturally create hormones. Plant growth-regulating chemicals can be divided into five groups: auxin, gibberellin (GA), cytokinin, ethylene, and abscisic acid (ABA). Each group primarily consists of both synthetic and naturally occurring hormones.
- It is necessary to keep up-to-date records of all purchases; data observation; labour engagement and attendance; sales; pest and disease outbreaks; permanent and temporary stocks and movement registers. Multiple records

detailing expenses and earnings are kept in separate books, such as purchase books, sales books, ledgers, cash books, dispatch registers, etc.

Check your progress

1. What do you understand from the maintenance of nursery?
2. Discuss the importance of fencing in nursery.
3. Describe the different kinds of nursery?
4. What do you understand from the plant nutrients?
5. Explain briefly about the groups of plant-growth-regulating compounds.
6. Describe the watering, weeding and nutrient Management in Nursery.

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Unit 8: Asexual Method of Propagation:

Unit Structure

8.0 Learning Objectives

After going through this unit, you will be in a position to:

- Explain the asexual method of propagation
- Study different methods of asexual propagation
- Advantages and disadvantages of sexual and asexual methods of plant propagation

8.1 Introduction

Plants cannot increase their population to survive in the natural world without the process of propagation, which is a crucial component of the plant life cycle. You may have observed how gardeners propagate quality plants to be used in the current or upcoming season. Plants have been intentionally or unintentionally propagated for hundreds of years. Propagating plants is a crucial first step in maintaining a specific plant's desirable traits from one generation to the next. For propagating horticulture plants, various techniques may be applied. Both asexual and sexual techniques are among them. These techniques for propagation can be applied to horticulture plants based on their significance and usefulness. One of these is asexual propagation, which uses a plant's vegetative elements, such as cuttings or segments of the stem, budding, layering, grafting, etc. While plants propagated from seeds are not always true to their original parent plant, plants propagated by asexual means are true-to-type. Certain plants can reproduce asexually or sexually at will, whereas others can only be reproduced sexually or by asexual means. Bananas are only propagated vegetatively, although fruit plants like papaya are commercially propagated through seeds. Mango, guava, citrus, grapes, apple, and so forth are propagated using both techniques. Vegetable crops and ornamentals are no different.

8.2 What Are Asexual Methods of Propagation?

Asexual propagation is the process of multiplying a plant using any portion other than its genuine seed. It's also referred to as the vegetative propagation method. Plant parts such as stems, leaves, branches, cuttings, branch layering, budding, grafting, etc. can be used for propagation. The plants that are produced using this technique are true to type.

8.3 Propagation by Seed

When using an asexual technique, seed production is mostly taken into account when true-to-type plants are anticipated as the end output. Only in the case of polyembryonic seedlings is it true. As the name suggests, polyembryony describes seeds that contain many embryos. The term "gametic and sexual embryo" refers to an embryo that is created when male and female gametes unite, while the other embryos are created by simple mitotic division of nuclear embryo cells without the assistance of male gametes. Nuclear embryos are a frequent occurrence in citrus and mango.

8.4 Propagation by Cutting

Using a portion of a stem, root, or another plant part for plant multiplication is known as cutting, which is a type of vegetative propagation. Cutting-derived plants are true to their mother plants. This technique is frequently applied to plants since they root easily and readily, making plant multiplication swift and expensive. Commercial cuttings are used to produce ornamental plants like carnations, chrysanthemums, and numerous foliage plants, as well as fruit plants like phalsa, Baramasi lemons, and grapes, among others.

The two most popular ways of propagation are hardwood and softwood cuttings, which are made from completely developed and immature tissues, respectively. Immature angular cuttings are not favored over round cuttings. Cuttings of hardwood are easily prepared from shoots that are at least a year old. Cuttings are taken from deciduous fruit plants, such as figs, pomegranates, grapes, and phalsa. Cuttings from decorative foliage plants and evergreen fruit trees, such as Baramasi lemon, can be prepared in the spring (February to March) and rainy season (August to September). Typically, 3-5 bud cuttings, around 15-20 cm in length, are taken. To improve nutrition absorption, the bottom cut is made slantingly directly below the bud or node. The uppercut is made as far away from the upper bud as feasible to prevent drying and at right angles to minimize the size of the wound. The cuttings should be left to dry after they are processed. Fruit plant cuttings are typically bundled into small bundles of 20 to 25 cuttings, buried in wet soil or sand for a certain amount of time to promote wound healing (a process known as "callusing"), and then planted in the field to take root. Ornamental plant cuttings are either directly planted into media for rooting, or they are dipped in water to ensure proper absorption of water, followed by the application of rooting hormones to the lower cut below the node.

8.5 Advantages and Disadvantages of Propagation by Cuttings

8.5.1 Advantages of Propagation by Cuttings

i. It's an easy, affordable, and practical solution.
ii. The costs are kept to a minimum.
iii. A great deal of technical expertise is not needed.
iv. There are no intricate issues about stock-scion connections.
v. Quick multiplication is feasible in a brief amount of time.
vi. Traveling is simple.

8.5.2 Disadvantages of Propagation by Cuttings

i. Not every plant can root readily.
ii. It is not possible to fully benefit from rootstock.

8.6 Propagation by Layering

Using layering, roots are induced on shoots while they are still joined to their mother plants. For fruit and decorative plants that are difficult to root after being separated from their mother plants, this is an alternate propagation technique. Mound, ground, and air layering are the three most popular layering techniques.

8.7 Advantages and Disadvantages of Propagation by Layering

8.7.1 Advantages of Propagation by Layering

i. It is simple to do and doesn't need a lot of equipment.

ii. Dependable technique for plant species that are difficult to root.

iii. Doesn't need exact environmental control parameters.

iv. It is feasible to grow big plants quickly.

8.7.2 Disadvantages of Propagation by Layering

i. Comparatively more scion wood is needed than with other techniques.

ii. It is not feasible to generate a large number of plants quickly.

iii. The resulting plants have fragile, tiny roots.

iv. Rootstocks' advantageous benefits are not usable.

v. Layer mortality is typically high.

8.7.3 Methods of Layering

i) Air Layering: Air Layering: This technique involves layering in the air, as the name would imply. More specifically, while the shoot is still linked to the mother plant, it is the shoot that undergoes roots. This approach involves choosing a straight, healthy shoot that is one year old, and then removing a 2.5-cm-tall ring of bark that is located directly below a bud. This section is surrounded by moist sphagnum moss, which is covered with a polythene strip. It has a very high water-holding capacity and weighs relatively little. Any material that can hold moisture for an extended length of time can be used in its place if sphagnum moss is unavailable. While allowing gaseous exchange, the polythene covering keeps moisture within. Additionally, there is no need to water the layers afterward, saving a significant amount of labor. Another name for this layering technique is the "goottee" approach.

Air layering is possible with decorative plants such as guava, litchi, sapota, loquat, etc. in February through March and July through August. A few weeks later, the roots have grown and are visible through the polythene layer. Then, at least 15 days before they are permanently removed from the mother plant, the rooted layers on the parent branch should have a halfway cut. A few leaves or a tiny stem are kept at the moment of separation. Additionally, it is preferable to put these rooted layers in a nursery where they will receive more care than if they are planted in the wild. In February or September through October of the following year, these layers can be sown in the fields.

ii) Ground Layering: Using this technique, a plant branch that is close to the ground is selected, and a 2.5 cm-diameter ring of bark is cut off right below the bud. Then, while still linked to the mother plant, this branch is twisted and buried in the ground. Watering the soil regularly keeps it moist. The baby plant splits off from the mother plant after a few weeks of root formation. It is important to separate plants so that the newly developed roots accompany the severed plant. Before being planted in the fields, these young plants should ideally be grown in nursery rows or pots to allow for the development of a stronger root and shoot system. This technique is frequently used to propagate ornamentals like jasmine and Baramasi lemons, among other plants.

iii) Mound Layering, also known as "Stooling": Using this technique, the plant is returned in either July or February. The fresh shoots emerge from the earth in April and September. These shoots have a bark ring removed, and the soil is mostly covered over them. During the wet season, the rooted stools from April stooling are separated, and those from August stooling are removed in the spring. These stools will be planted in a nursery once they have split off from the parent plant. This technique, sometimes called stool layering, is employed in guava growth. Early rooting can be facilitated by applying hormones for rooting around the ring using a paintbrush.

8.8 Propagation by Budding

One bud is placed into the rootstock using the budding technique. This process is quick and simple. In comparison with cutting and grafting procedures, this propagation technique preserves budwood. The ideal moment for budding is said to occur when the bark begins to slip on the scion and the stock. This demonstrates the activity of the cambium, the tissue in charge of union. Typically, this technique is used in the spring and during the rainy season. T-budding, patch-budding, and chip-budding are the three most used budding techniques.

8.8.1 Methods of Propagation by Budding

There are various budding techniques, which are thoroughly explained below:

i. **T-Budding**: Another name for this technique is shield budding. The stock (stem), which is located 15–20 cm above the ground, has a horizontal cut that is approximately 1/ 3rd of the distance around the stock. Using the ivory end of the budding knife, make another vertical cut 2-3 cm long downward toward the center of the horizontal cut, loosening the bark flaps to reveal the bud. The bud is taken out of the bud stick once the 'T' has been formed in the stock. A slicing incision is made starting at a place on the bud stick, around 1.25 cm below the bud, and continuing below, approximately 2.5 cm above the bud, to remove the covering of bark encasing the bud. To remove the shield piece, another horizontal cut is performed 1.25 to 2 cm above the bud. A very thin chunk of wood is removed coupled with the shield. After that, the shield is pushed beneath the two elevated bark flaps until the stock's upper horizontal cut corresponds with it. The shield should firmly adhere to the bark, leaving the bud visible but the two bark flaps covering it. To securely hold the two parts of the bud union together until the union is finished, polythene strips should be wrapped around it. T-budding is possible year-round as long as cell sap runs unhindered. Most fruit trees, roses, and a few other wooden ornamental plants undergo this process in the spring, from March to April, or during the rainy season, from July to September. This is an especially popular way for growing roses and citrus trees.

ii. **Patch budding**: It is a highly effective method for growing guavas, yielding a success rate of 60-70% when carried out in May and June. Use freshly cut, angular budwood from the current growing season for the scion. At a distance of roughly 15-20 cm above ground, a square or rectangle-shaped patch or piece of bark, measuring 1.5 cm in width and 2.5 cm in length, is cut away from the rootstock. Care must be taken while removing a comparable patch with a bud from a bud stick so as not to fracture the bark underneath the bud. After that, the patch is moved to the rootstock, smoothly adjusted, and fastened with a polythene strip right away. Instead of using a single bud as the scion, a patch with two buds can be utilized for greater success. This technique is known as the "improved patch budding" technique.

iii. **Chip Budding:** This technique is typically used right before fresh growth begins, while the stock and scion continue to remain dormant. Using this technique, a 2.5 cm long slanting cut is made into the stock, and then a second cut is made at the bottom of the first cut to remove a bark chip. To match the cuts specified in the rootstock, the bud within the scion wood was removed in the same manner. This bud-adorned chip is easily inserted into the rootstock cut, being careful to ensure that the stock and scion's cambium layers join on at least one side. To keep the bud from drying out, it is then knotted and wrapped with a polythene strip.

8.8.2 Advantages and Disadvantages of Budding

8.8.2.1 Advantages of Budding

i. Compared to grafting, this mode of propagation is faster and more effective.
ii. Less scion material is needed.
iii. It helps plants that discharge a lot of wound gum (stones fruits) after an injury that was transmitted to the xylem during the grafting process.
iv. Because the union is stronger than with grafting, there is less chance of storm damage and severe winds harming the budded plant.
v. Compared to grafting, this method of propagation is somewhat simpler.

8.9 Propagation by Grafting

Another technique for vegetative propagation is grafting, which involves joining two plant sections so that they merge and grow into a single plant. The scion twig in this manner has more than two buds upon it. Fruits like pears, peaches, plums, almonds, mangos, etc. are frequently grafted. Grafting is done during dormancy in seasonal fruits like peaches, plums, and almonds, but during active development in mango trees.

8.9.1 Methods of Grafting

There are several grafting techniques, including veneer, approach, side, cleft, and tongue grafting.

8.9.1.1 Tongue Grafting: When the diameters of the stock, as well as the scion, are equal, this technique is frequently applied. Initially, a 4-5 cm long, smooth, sloping cut is made on the rootstock. A second downward cut is made, this time about 1/3 of the way from the top and measuring 3–4 centimeters in length. The scion wood is similarly sliced, precisely matching the cut specified in the rootstock. After that, the scion, which has two to three buds, is firmly placed into the rootstock, being careful to ensure that the cambium layers of the scion and stock join on at least one side. Next, a polythene strip is used to wrap this.

8.9.1.2 Cleft Grafting: Another name for this is wedged grafting. When tongue grafting is not an effective technique and the rootstock is wider than the scion, this procedure is helpful in the nursery. Using this technique, a stock with a thickness of up to 8 cm can be grafted. A secateurs or blade is used to cut the rootstock that will be grafted smoothly. Next, it is divided in half, separating it by roughly 4 cm. With three or four buds, the bud stick is trimmed at its lowest point into a wedge shape, with the outside side being somewhat wider than the inner. To ensure that both the cambium layers of the stock and scion are precisely matched, the lower bud of the scion should be situated just well within the stock.

8.9.1.3 Approach Grafting: Approach grafting is the name given to this technique of grafting because the scion is approached by the rootstock whereas it continues to be linked to its mother plant. As an alternative, the stock is sown beneath the canopy of the mother plants, which have been taught to have low heads. The ideal time to approach graft is during the final week of July or the start of the week of August. The rootstock and scion diameters for this procedure should be almost equal. Matching sections of the scion and stock are cut, and a thin section of wood, about 4 cm long, and a slice of bark are removed. After that, they are brought together, being careful to ensure that at least one side of their cambium layers makes touch.

Then, using polythene strips or any other kind of tying material, these grafts are securely linked. To speed up the union, the scion and stock plants receive frequent irrigations. In roughly two to three months, the union is finished. The scion branch is then sliced through about half of its thickness. After about a week, if the shoot doesn't show any signs of wilting, it has fully separated from its parent plant. Should the scion begin to wither, it indicates that the union is incomplete. In these situations, once the union is complete, the scions separate from the parent plants after a few days. The process is frequently used with mango. "Inarching" is another term for this technique.

8.9.1.4 Side Grafting: At a height of approximately 15-20 cm above the ground, a three-sided, rectangular cut measuring 4 x 1.25 cm is produced on the rootstock, and the bark of the delineated area is peeled aside from the rootstock. To reveal the cambium, a corresponding cut is also performed at the scion's base. It is best to prepare the scion well in advance of the grafting process. For this purpose, nutritious scion shoots from the most recent mature flush are chosen. The terminal buds of the chosen scion shoots have to be plump. Extract the leaf blades after choosing the scion shoots, being careful to preserve the petioles. The petioles will drop and the terminal buds will swell in around 7 to 10 days. At this point, the stock should be grafted onto the scion stick once it has been separated from the mother tree. To bring the exposed cambia of both of the components into close contact with one another, the previously prepared scion is placed beneath the rootstock's bark flap. The rootstock's bark flap is arranged in its original place. Next, a strong polythene strip tie is used to secure the graft union. To promote the growth of the scion, a portion of the rootstock is removed once the grafting procedure is finished. The rootstock section above the union of grafts needs to be removed once the scion has grown and its leaves have become green. The months of March through October are good for side grafting; however, the months of May and October are not as successful. Mangos are widely propagated using this technique.

8.9.1.5 Veneer Grafting: Using this technique, a 4 cm-long, shallow downward cut is made on the rootstock between 15 and 20 cm above the ground. To remove a portion of wood and bark, a second, short, downward cut is made at the base of the first cut, joining it. The preparation of the scion is the same as for side grafting. For the cambial layers of the scion shoot and rootstock shoot to match, the cuts on both should be the same width and length. Next, the ready-made scion is placed within the rootstock and fastened firmly using a polythene strip. The stock is reduced once the union is finished to allow time for veneer grafting.

Summery

You have learned about many asexual plant propagation techniques and nursery management tactics in this course. Plants can be mass-propagated using asexual techniques. The technique used will vary depending on the plant being propagated. Certain fruit plants, such as papayas, can only be commercially propagated through a seed, which is asexual propagation; in contrast, bananas can only be propagated through vegetative (asexual) techniques, such as suckers. With both asexual and sexual methods, which have benefits and drawbacks, the majority of horticultural plants are propagated. While homogeneous plants cannot be produced via sexual propagation, true to-type plants can be produced using an asexual technique. Understanding the many contemporary nurseries and the techniques—such as rooting hormones or media—that are employed to generate commercially viable plants is also crucial for the effective production of nursery plants.

Check your progress

1. What does approach grafting mean to you?
2. Which fruit plant is the subject of this plant propagation method?
3. What is the propagation method of ground layering?
4. What are the methods used by budding?
5. A brief outline of tongue and cleft grafting methods?
6. List the three benefits of propagating plants asexually.

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Unit 9: Sexual Method of Propagation

Unit Structure

9.0 Learning Objectives

After going through this unit, you will be in a position to:

- explain different methods of sexual propagation,
- aspects of seed production,
- describe seed germination,

- define dormancy, and
- advantages and disadvantages of sexual plant propagation

9.1 Introduction

You may have observed how gardeners propagate quality plants to be used in the current or upcoming season. Plants have been intentionally or unintentionally propagated for hundreds of years. Propagating plants is a crucial first step in maintaining a specific plant's desirable traits from a single generation to the next. For propagating horticulture plants, various techniques may be applied. Both asexual and sexual techniques are among them. Sexual propagation is the process of propagating a plant mainly by producing zygotic embryos for use as seeds. Asexual propagation, on the other hand, is defined as propagation that occurs either by segmenting vegetative portions or by using vegetative embryos (nucellar embryos). Plants can be propagated by either an asexual or sexual manner, depending on the plant's value and application. To breed new types, the sexual technique of propagation is typically employed.

9.2 Propagation Methods

Since you are aware, there are various ways to propagate the plants. These include both vegetative and non-vegetative methods. The former is sometimes referred to as asexual propagation, whereas the latter is known as sexual propagation. The main topic of discussion in this unit will be sexual plant propagation techniques.

9.3 Sexual Methods

The sexual mode of propagation is applied when a plant is multiplied through seeds. The reason for this is that seed is created when the male and female gametes of both parents fuse together. You may be curious about the process of seed production and how it is used to propagate various plants, particularly horticulture species. Papayas and other fruit plants are commercially reproduced using seeds. Similarly, as wooden fruit plants are essentially composite structures sold in stores, made up of a scion and a rootstock, the rootstock is mostly spread by seeds.

9.4 Seed Production

The state of the seed during harvest from the plant, the surrounding environment, including the type of soil and moisture levels required for germination, and the appropriate separation distances established in cross-pollinated crops are all factors in seed generation. Above importantly, the seed needs to remain viable for extended periods to be produced commercially. You need to understand seed, the seed production process, maturity, ripening, compounds that can protect seed within soil after sowing or during storage, and the elements that affect seed production if you want to get engaged and succeed in seed production.

9.4.1 Seed

According to botany, a seed is a developed ovule that has enclosed an embryo, typically the product of sexual fertilization. In the flower's ovule, gametes from both the male and female can fuse to produce a single cell known as a zygote, or vegetative, or unfertilized, reproductive cells can generate seed.

9.4.2 Seed Components

The endosperm, embryo, and seed coat are the three main parts of the seed. These elements that come from nature have a certain function to perform. The seed coat shields the developing embryo inside the seed from environmental anomalies such excessive heat, light, or humidity, while the endosperm feeds the growing embryo until it can sustain itself.

9.4.3 Quality Seed Production

Every nursery producer should be committed to producing high-quality seeds. The following characteristics of high-quality seed are desired:

1) Seeds, like nuclear seeds, should be genetically faithful to type.

2) The shape and size of the seed should be uniform.

3) It must not be a blend of weed or other seeds.

4) The duration of its viability should be extended.

5) Seeds should be free of disease-causing organisms and insect pests.

9.5 Process Involved in Seed Production

9.5.1 Pollination

Pollination is the process that occurs during flowering when another pollen grains land on a flower's stigma and germinate to produce a pollen tube. The stigma must be receptive and the pollen ripe or viable for effective pollination to take place. The horticulture plants can be self-pollinated or cross-pollinated, depending on the conditions for pollination. When there is cross-pollination, pollen might come from any flower, but in self-pollination, the stigma is pollinated by the same flower's pollen. Prior to pollination, tests for stigma receptivity, pollen germination, and pollen viability should be conducted.

a) Pollen viability: A biochemical test can be used to assess pollen viability. Pollen grains are placed on a cavity slide for this test, and they are dyed with an acetocarmine (1-2%) solution. Stain-treated pollen grains are regarded as viable, while unstained pollen grains are regarded as non-viable. The dye is applied to the live protoplasm.

b) Pollen germination: Research on pollen germination, conducted before pollination, ensures successful fertilization and robust seed yield. In cavity slides, the process of germination for pollen is investigated at various sugar solution concentrations between 10 and 30 percent. The type and species of the pollen determines how long it takes for it to incubate in a sugar solution.

c) Stigma receptivity: Stigmas that have a sticky quality are often thought to be receptive. Stickiness aids in retaining pollen for a brief amount of time until it develops into a pollen tube and travels toward the ovary. This is particularly true for citrus fruits and certain flowering plants, as stigma becomes shiny, sticky, and vibrantly colored when it is open to receiving.

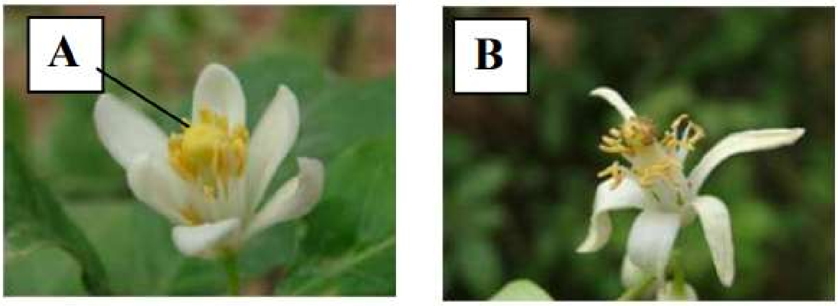

Fig 1: Citrus flower showing Receptive (A) and Non Receptive (B) stigma.

Cross-pollination occurs spontaneously in the majority of horticultural plants. Natural cross-pollination can occur, or it can be done by hand (particularly when producing hybrid seeds). Natural cross-pollination is accomplished by birds, insects such as house flies (mango) or honey bees (citrus and blossom), or the wind (date palm).

9.5.2 Fertilization

Two male gametes are released into the embryo sac during this phase from the pollen tube; one of them combines with a female gamete to form a zygote. Put another way, following successful pollination, the pollen grains land on the flower's stigma and make their way to the ovule. The pollen grains release their two nuclei inside the embryo sac. Eight nuclei, including the cells of the egg, two synergists at one end, three antipodal nuclei on the other, and two polar nuclei close to the center, are developing in the ovule in the meantime. The pollen tube's two polar nuclei combine to form endosperm when one of its nuclei unites via the egg cells, forming the seed embryo.

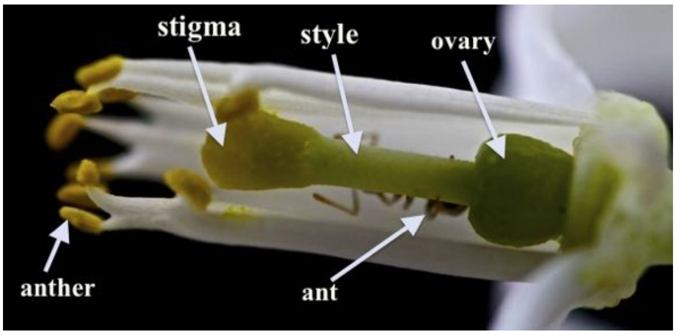

Fig 2: Reproductive parts of citrus flower.

9.6 Polyembryony

This situation refers to the development of many embryos within a single plant seed. Numerous plant species experience this phenomena, but fruit species like citrus and mango exhibit it the most. Both of zygotic as well as apomictic embryos are formed in polyembryonic species, negating the need for fertilization stimulus.

9.7 Apomixis

It is the outcome of creating an embryo that eschews the typical meiosis and fertilization procedure. The seedlings that are produced will have the same genotype as their seed parent. Stated differently, asexual seed production occurs. One significant example of apomixis is citrus. Growing rootstocks is one of the most significant uses of apomictic seedlings due to their robustness, homogeneity, and virus-free nature.

9.8 Seed Germination

The process by which a mature seed becomes a new plant is known as germination. To put it another way, germination is the process by which the plumule (branch) and radicle (root) emerge and begin to produce seedlings. The environment must be suitable and the seed viable, which means the embryo would be alive and able to germinate, for germination to begin. There are several stages involved in seed germination:

i. a sharp rise in water absorption;
ii. a lag phase, during which there is minimal water absorption; and
iii. an increase in the fresh weight of the seed, resulting in the development of roots.

9.8.1 Seed Viability

A viable seed is the only one that germinates. Stated differently, only seeds containing living embryos sprout. A few days to several years may pass before a seed becomes viable, depending on the type of plant, the environment, and several other variables.

9.8.1.1 Elements Affecting the Viability of Seeds

The following variables have an impact on seed viability:

i. **Environmental Conditions:** Seed viability is impacted by the weather that prevails during the stages of seed maturation, ripening, and harvesting. When seeds are mature, warm, dry weather often encourages the formation of high-quality seeds; on the other hand, unfavorable weather conditions such as frost, heavy rain, or even drought during seed harvesting can negatively impact the viability of the seeds.

ii. **Mechanical Damage**: Seed viability is negatively impacted if a seed sustains mechanical damage during harvest or transportation. Damage to developing embryos has a specific effect on seed viability in relation to seed germination.

iii. **Genetic Factors:** The viability patterns of seeds from several species or variants within a species may differ.

iv. **Storage Conditions:** Seed viability is greatly influenced by the temperature, light, and humidity during seed storage. High relative humidity generally reduces the seed's life. If seeds are stored at extremely low temperatures, they can remain viable for extended periods (cryopreservation). All kinds of seeds, however, cannot be kept in storage at extremely low temperatures.

9.8.1.2 Method to Detect Seed Viability

There are various techniques for determining the viability of seeds; the following are the most popular ones:

a) Germination test: This entails seed germination on synthetic media and calculating the proportion of germination to cultivated seed. This is a common practice in many plant species, particularly horticulture crops, to guarantee seed viability. Seeds can be germinated in Petri dishes, filter paper layers, or plastic trays, or containers filled with sand, soil, perlite, or vermiculite.

b) Excise embryo test: an embryo removed from the mature seed is cultivated in Petri dishes having moist filter paper lining them, or on artificial media. When testing the viability of seeds in species of trees whose embryos require extended periods of "after-ripening" before real germination occurs, the excised embryo test is typically utilized.

c) Tetrazolium Test: Time-consuming and labor-intensive are the traditional ways of determining a seed's ability to germinate in sand or petri dishes. To test for germination, the majority of non-dormant fruit seeds need seven to eleven days, while dormant seeds take a few months. Citrus seeds are kept under certain storage settings since they quickly lose their vitality. It is therefore preferable to have a rapid test that provides an approximate estimate of seed germinability. It takes 4–24 hours to determine the viability of a seed using the tetrazolium test. Its unique benefit over other biochemical tests is its ability to examine specific seed organs and tissues essential for seed growth. Seed embryos that are able to germinate and grow normally possess reducing enzymes that cause the nearly colorless solution of triphenyltetrazolium chloride to become a visibly noticeable crimson stain on the sections of the embryo tissue that have been sliced.

Seeds are immersed in a solution of 2, 3, 5-triphenyltetrazolium chloride (TTC) (0.1–1.0%) for a few hours in order to conduct this test. The TTC is transformed into an insoluble red chemical by living tissue. As a result, depending on when they are incubated, healthy seeds can turn red all the way through, while non-viable tissues or seeds remain colorless.

9.8.2 Seed Sowing

It may or may not be necessary to pre-treat fruit seeds before sowing because they vary in size, shape, seed coat, and chilling requirement.

9.8.2.1 Pretreatment

Fruit seeds such as papaya, phalsa, citrus, jamun, mango, and loquat don't need to be treated differently before being sown. The rocky endocarp that houses the seed makes it extremely difficult for the seed to germinate while in ber. Seeds should be immersed in a 17–18% salt solution for a full day prior to planting. Another way to sow the seeds is to break the hard shell. Before planting, guava seeds should be immersed into water for a minimum of two weeks. The time needed for germination can also be shortened by immersing the seeds into boiling water for roughly five minutes. Before they are planted in the ground or in raised nursery beds, the seeds of pears, peaches, and plums must be stratified. Seeds can be sowed in various states depending on the cultural media. For example, removing the outer seed coat (testa) and sowing the seed in soil or poly bags might improve citrus seed germination. Both the testa and the tegmen, the inner seed coat adjacent to the testa, should be removed at the same time when seedlings are to be grown in vitro.

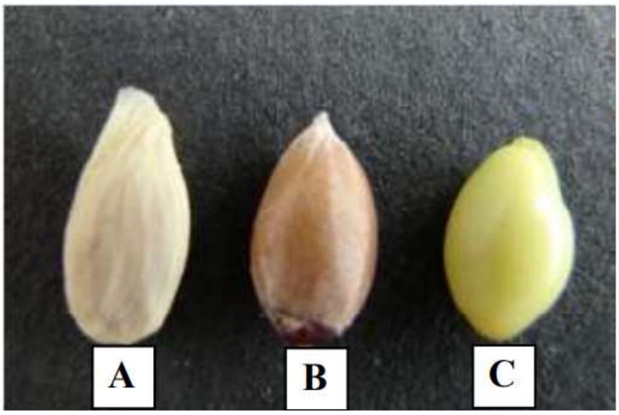

Fig 3: Citrus seeds (A), without testa (B), without testa and tegmen (C).

9.8.2.2 Method of Sowing

Raised or level nursery beds can be used to sow the seeds. Mango, Ber, Loquat, and Jamun seeds are typically sown on level beds, but citrus, guava, and phalsa seeds are typically sown on 15-20 cm elevated beds in order to promote drainage. The seed beds' soil needs to be finely ground and combined with well-rotted farmyard manure. The seed beds are prepared; they are typically 1.2–1.5 meters broad and 2.0–2.5 meters long, with irrigation furrows that are 60 cm wide in between. The seeds are planted in rows, spaced 10-15 cm apart and 2-4 cm deep. To stop crust formation, a thick layer of sand mixed with leaf mold mixture is applied over the seed. After seeding, seed germination takes place in two to three weeks. Evergreen fruit seedlings are transplanted in February, March, and August–September, while deciduous fruit seedlings are transplanted in December and January.

9.8.2.3 Media for Sowing Seed

Depending on the need and the value of the seed to be propagated, the seeds could be sown on a variety of medium. The following qualities should be present in a suitable media:

i. It needs to be cost-effective.
ii. It ought to permit appropriate aeration and drainage.
iii. Sterilization is the best option.
iv. Weed seeds should not be present.
v. It needs to supply enough nourishment to encourage the growth of seedlings.
vi. Its pH need to be ideal.

The commonly used media for sowing seeds are as follows:

(A) **Soil:** The most popular natural medium for seed sowing is garden soil. The composition of soil's organic and inorganic constituents defines its texture and structure. The proportions of sand, silt, and clay in the soil determine its texture. To promote the growth of seedlings, soil should generally have adequate drainage and be nutrient-rich.

(B) **Sand:** It can also be utilized as a seed-sowing medium, particularly for seeds were damping off is a frequent issue. For example, the best medium to plant papaya seeds in is sand.

(C) **Peat:** It mostly consists of the aquatic vegetation's partially degraded components. The most popular propagation medium is peat moss.

(D) **Perlite:** A silicaceous, grey-white substance that originated from volcanic eruptions. With a pH of 6–8, perlite is a sterile medium having a high capacity for cation exchange and water retention. When used in conjunction with other propagation media, it can increase aeration in a mixture and has no mineral nutrients. Perlite's homogeneity and light weight make it an excellent choice for improving drainage and aeration.

(E) **Vermiculite:** This substance is micaceous. Because of its great capacity for cation exchange, vermiculite can retain nutrients and release them gradually. Its plate-like particles aid in drainage and aeration while also having a very high water-holding capacity.As a result, it solves the "damping off" issue that would otherwise frequently arise with dirt acting as the media. Vermiculite can offer magnesium and potassium and has good exchange and buffering properties.

Fig 6: Rooting media (A) Vermiculite (B) Perlite

(F) **Mixture:** The ideal media for seed sowing is typically a blend of soil, sand, and FYM. This is due to the fact that this kind of media satisfies nearly every requirement for being suitable media. You can mix peat, perlite, and vermiculite separately or with soil and sand. Typically, a combination of 2:1 Peat: Perlite or Sand and 2:1:1 Peat: Pertlite: Vermiculite can also be utilized. These rooting medium are somewhat pricey seed sowing media, which means they should only be chosen if traditional media, such as sand, soil, and their mixture, are unable to sustain a sprouting of seeds or if the importer of seeds requires it.

Above all, before utilizing any chosen media for seeding, it is crucial to ensure that it has been rendered sterile (by pasteurization). Using pasteurized soil helps shield young seedlings from the fungal disease known as damping-off. Additionally, pasteurized soil helps deter pests, illnesses, and weeds.

9.8.3 Phases of Seed Germination

9.8.3.1 Water Uptake

Once fully developed and extracted from the fruits, the majority of the seeds have little moisture in them. The seeds suddenly absorb water during this stage of germination. It is also known as the "hydration phase," during which water is taken up by dry seeds through the processes of osmosis and imbibation, softening the seed coat along with other coverings and hydrating the protoplasm. The seed swells and the seed coverings break upon imbibition of water, assisting the protoplasm in restarting metabolic activity through its activation of enzymes. Cell elongation is the outcome of the hydrolytic enzymes' ability to break down complicated dietary materials into simpler forms that the embryo can easily translocate and absorb. In this stage, the seed expands in size.

9.8.3.2 Lag Phase

During this time, there is either no water intake or very little. But seed has a very active physiological system. Cellular processes essential to healthy germination occur during this phase.

9.8.3.3 Radicles Emergence

It is the first instance of germination that can be seen. The term "radicle" refers to the root's growth point.

9.8.3.4Plumules Emergence

The plumule is a growth point located above the cotyledons on the upper end of the embryonic axis.

9.9 Environmental Factors Affecting Seed Germination

A number of variables influence seed germination. Water, light, aeration, temperature, and infection incidence are the most crucial of these.

9.9.1 Liquid

One important aspect influencing seed germination is the presence or absence of moisture. Moreover, seeds should have access to the ideal quantity of water. Insufficient water content causes seeds to wither away, while an excessive amount causes anaerobic conditions that kill growing seeds. The type of seed coat, the ambient temperature, and the amount of moisture present are just a few of the variables that affect how quickly water is absorbed.

9.9.2 Light

It is an additional significant component that influences seed germination. It ought to be at its best. Different seeds require varying amounts of light. Furthermore, light may not be the only reason preventing some seeds from germinating. Certain plant seeds require precise amounts of light to germinate; else, they will not. While photoperiod along with wavelength have a more noticeable impact on seed germination, light intensity has a relatively smaller influence. Generally speaking, red light promotes seed germination, whereas far red light inhibits it. In addition to light's existence or absence, light quality affects how well seeds germinate.

9.9.3 Aeration

For quick and consistent germination, gas exchange between the embryo and the germination media is necessary. The respiration activities in the developing seed depend on oxygen. Over-wetting of seeds restricts the availability of oxygen, which in turn impacts seed germination. In another way, because germination occurs at a very high rate, sufficient gas exchange and supply between the embryo and the germinating medium are required for uniform and quick germination as well as the growth of seedlings that follow. The availability of water is directly correlated with aeration. Less leaching and hence less aeration within the germination media will occur with more water.

9.9.4 Temperature

It should be at its best. The minimum temperature is the lowest that germination may occur at, while the maximum temperature is the greatest that germination can occur at. The type of seed determines the required temperature. For example, seeds that need a low temperature to germinate will not germinate at a high temperature, and the opposite is also true. The percentage and rate of seed germination are impacted by temperature. Most plant species have an ideal temperature range that they need to germinate, and any temperature below or beyond that range will prevent germination.

9.9.5 Incidence of Infections

Infections with fungi or bacteria restrict the germination of seeds in some circumstances, particularly when the surrounding humidity is inappropriate. Some fungi cause mortality in seedlings by attacking immature seedlings. A typical issue with papaya seedlings is damping off.

9.9.6 Acidity

Salts have an impact on seed germination when they are present in soil or water, especially at concentrations that are greater than ideal. When the growing media is exposed to light and receives irrigation with inadequate water, salinity becomes an issue. Regular light irrigation causes salt to accumulate on the top soil layer, where seeds are often put, which prevents germination.

9.10 Seed Dormancy

Dormancy is the absence of viable seed growth brought on by either internal or external variables. When extracted from the fruit and placed in ideal moisture, temperature, and aeration conditions, the seeds of tropical and subtropical fruits (mango, citrus) germinate right away. Nonetheless, even in favorable environmental conditions, the viable seeds retrieved from temperate fruit plants such as plum, pears, and peaches do not germinate; this phenomenon is known as dormancy. Such fruit plants are fortunate to be shielded by nature from harsh winters. The dormancy of these seeds must therefore be understood, as well as the elements that contribute to or overcome it.

Dormant seeds may have either endogenous or external causes. Usually, one of two factors causes exogenous seed dormancy: either the hard seed coat prevents water and gasses from reaching the developing viable embryo, which prevents seed germination, or both. Low seed germination in the case of endogenous seed dormancy can be attributed to physiological immaturity of the embryo, a lack of certain endogenous growth boosters, or an excess of endogenous development inhibitors.

9.10.1 Types of Dormancy

The following describes the various forms of dormancy that seeds might experience:

(A) **Exogenous:** Exogenous variables are those that induce dormancy through external means, which can be mechanical, chemical, or physical in nature. These are listed below:

i. **Physical:** A stiff seed coat that prevents the seed from absorbing solutes or water or from aerating itself may be the cause of dormancy. It is important to note that, even in these situations where the embryo in the seed is viable, seed germination is unable to take place. As a result, dormant seeds do not sprout until the hard seed coat is broken or eliminated. Peach and almond seeds, for instance, have a hard seed coat that must be thinned by acid scarification or sandpaper rubbing. Such strong seed coverings are naturally eroded by constant weathering, microbial attack, or seed transit through animal digestive tracts.

ii. **Mechanical:** This describes seed coverings that, despite being permeable to water, are too tough to let the embryo to enlarge during germination. In all species, dormancy is never caused solely by hardening of the seed covering; nevertheless, hardening in conjunction with other conditions may induce a delay in seed germination.Certain seed coats, for instance, appear to be permeable to gasses and water but have an extremely high mechanical resistance that prevents the embryo from expanding. Unless these seed coats are softened, germination will not occur. Therefore, in order to overcome such dormancy, the seed coating must be removed.

iii. **Chemical:** Chemicals, also referred to as inhibitors, can occasionally prevent seeds from germinating because they have been found within the seed coverings. Germination inhibitors, like as phenols and ABA, build up in the fruit and seed coverings throughout development and are the cause of it. During fruit development, these inhibitors build up in either the fruit coatings or the fruits themselves. In these situations, inhibitor leaching is necessary to guarantee regular seed germination.

9.10.2 Endogenous

In contrast to external causes, dormancy in this instance results from internal factors like morphological, physiological, and other aspects.

i) Morphological: If the embryo is still immature during the time on fruit ripening or maturity, dormancy of this kind is imparted. If you sow these seeds right away after the fruits are harvested, they won't sprout. This kind of dormancy can be overcome with the use of warm stratification.

ii) Physiological: It is believed to be regulated by external elements like light and temperature as well as endogenous plant growth chemicals. The embryo's internal components prevent germination. This kind of dormancy, which lasts for up to six months and vanishes when stored, is typical of temperate fruits including apples, pears, and peaches.Even in ideal circumstances, the latent embryos in these species' seeds prevent them from germinating. Inappropriate light or temperature during seed germination might also cause this kind of dormancy. Depending on the needs of a fruit crop, this kind of dormancy can be avoided by storing seeds between layers of moist sand at a cooling temperature for a few days to a few months. Fruit crop seeds with moderate chill requirements might take a few days to break dormancy, while those with high chill requirements might take several days.

9.10.3 Transplanting Seedlings

It is important to gently transfer the completely rooted plantlets or seedlings from the rooting media to the field. The most important thing to remember is that seedlings have to be transplanted on open fields at the ideal moment. To be more explicit, it is claimed that the type of fruit plant—evergreen, deciduous, etc.—will determine this. For example, to ensure 100% success, citrus seedlings (of rough lemon rootstock) are transplanted in the field during July and August. Winter is the ideal season for grapes because the seedlings are deciduous at this time. When young seedlings are little and there is less transplant shock, it is the best time to transplant them. Firm the soil after transplanting, and give it regular waterings.

9.11 Advantages and Disadvantages of Sexual Propagation

9.11.1 Advantages of Sexual Propagation

i. It is a reasonably priced technique for large-scale plant production.

ii. Nursery plant raising does not require specialist knowledge or expertise.

iii. Since most viruses cannot spread through seeds, plants that are reproducedfrom seeds are often virus-free.

iv. Nucellar seedlings can be used to produce true-to-type plants. This isparticularly true for polyembryonic seeds, such as citrus.

v. Due to their superior root systems, seedlings are used to propagate the majority of rootstocks.

vi. For some fruit plants, such as phalsa and papaya, seed propagation is their exclusive means of proliferation.

vii. Compared to plants created using asexual methods, plants grown from seeds often grow quickly and have a longer lifespan.

viii. Compared to plants grown vegetatively, seedling plants are more resilient to biotic and abiotic stressors.

ix. Seeds can be kept in storage for a longer period of time than vegetative tissues.

x. It's possible to develop seedlings that are better than the mother plant due to increased horticultural features.

9.11.2 Disadvantages of Sexual Propagation

i. Seed propagation is not usually used to create true to type plants, with the exception of nucellar seedlings.

ii. Because not all seeds are naturally polyembryonic, homogeneous progeny cannot be guaranteed.

iii. Compared to plants grown asexually, seedlings typically have a longer juvenile phase.

iv. Because most seedling plants are tall and vigorous, cultural activities are challenging.

v. Most plant seeds quickly lose their viability and cannot be kept for extended periods.

vi. Some fruit trees, such as bananas and pineapple, are incapable of being propagated from seeds because they do not yield viable seeds.

Summary

We have learned about various techniques for sexual plant propagation in this section. Plants can be mass-propagated using sexual ways, and new types can be created. The technique used will vary depending on the plant being propagated. The sole commercially available means of sexual propagation for some fruit plants, such as papayas, is seed. The sexual method offers benefits and drawbacks. Generally, depending on the particular plant species and breeding objectives, sexual propagation through seeds is a frequently used approach in horticulture with both advantages and disadvantages.

Check your progress

1. Explain germination.
2. How does seed germination respond to aeration?
3. What does morphological dormancy mean to you? And how it can be overcome?
4. How can the a person determine if stigma is receptive?
5. List the three main drawbacks of sexual reproduction.

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Unit 10: Biofertilizer

Unit Structure

10.0 Learning Objectives

After completing this unit, you will be able to:

- green manure and list the different types of manures
- brief introduction of Farmyard manure or FYM
- explain the biofertilizers and mycorrhiza application

10.1 Introduction

The primary obstacle facing humanity in the 21st century is providing food for the world's rapidly expanding population, particularly in emerging nations, without compromising environmental health. Millions of people suffer from chronic malnutrition and hunger today. In an effort to boost production, farmers have been using fertilizers and other agrochemicals carelessly, which has contaminated ground and surface water, degraded soil quality, decreased biodiversity, raised air pollution, and inhibited ecosystem functioning—all of which have an adverse effect on the health of the environment. When we talk about a substance that contains one or more of the essential elements (nitrogen, potassium, phosphorus, sulfur, magnesium, calcium, iron, molybdenum, manganese, copper, zinc, boron, chlorine, cobalt, sodium, vanadium, and silicon), we're talking about "fertilizing material or carrier."If excessive fertilizer use is not controlled, it can cause leaching in the soil, volatilization, acidification, and the release of ammonia, methane, nitrous oxide, and elemental nitrogen from the soil system due to a result of de-nitrification. The loss of water-soluble nutrients results in eutrophication, which is dangerous for aquatic and human health because it causes the luxuriant development of algae along with other water weeds. By boosting the effective nutrition accessible in the soil in an environmentally responsible manner, organic manures along with biofertilizers are the sustainable solution to the ecological issues brought on by the excessive or careless use of fertilizers. After breaking down, the organic manures provide mineral nutrients that enhance the soil's chemical, biological, and physical characteristics, hence increasing soil fertility. Organic acid is generated during the breakdown of organic matter, which aids in the gradual dissolution of minerals and increases their availability to plants. However, when applied to soils, seeds, or plant surfaces, biofertilizer is defined as "microbial inoculants containing living microorganisms that colonize the plant roots or plant interiors and promote growth by increasing the availability or supply of primary nutrients to the target crops." These technologies hold great promise for lowering the amount of traditional inorganic fertilizer needed for crop production that is sustainable. This lesson will provide you with an overview of biofertilizers and manures for managing agriculture sustainably.

10.2. Green Manuring

Crops raised with green manure are planted to boost or restore the amount of organic matter in the soil. Crops introduced into the cropping system through the practice of "green manuring" are either cultivated in-situ or are brought in from outside. The process of green leaf manuring entails gathering green biomass from adjacent locations, wastelands, and bunds and putting it into the soil. Essentially, adding young, green biomass to the soil that is receptive to rapid microbial degradation is what combined organic manure along with green leaf manuring entail. Since leguminous crops are able to fix nitrogen, the majority of green manure crops are members of this family. Among the important crops grown using green manure are Indigofera tinctoria, *Centrosema pubescens, Stylosanthes hamata, Tephrosia purpurea, Phaseolus trilobus, Sesbania aculeate, Glyricidia, Cassia auriculata, Ipomoea cornea, Derris indica, Thespesia populnea, Azadirachta indica, Pongamia glabra,* Calotropis, and other plants are examples of green leaf manure crops. Among the advantages of green manuring are the following:

i. The main benefit is that green manuring helps to improve the soil's chemical, biological, and physical characteristics.
ii. Green manuring replenishes organic matter in arable crop fields, preserving soil organic carbon, which is essential to the health of the soil ecosystem.
iii. Green manuring raises the nitrogen content of the soil due to the symbiotic link that exists between nitrogen-fixing organisms and crops, particularly those in the leguminous family.
iv. Green manures facilitate improved microbially mediated breakdown of organic matter by feeding the soil microbiota.
v. Green manuring enhances soil structure and significantly raises soil tilth.
vi. It has been observed that green leaf manure, such as *Azadirachta indica* and *Pongamia glabra,* can suppress insect pests.
vii. The translocation, or transfer, of nutrients from beneath the soil to the surface is aided by the growth of green manure crops.
viii. In terms of improving the soil, green manuring helps to restore sodic soils.
ix. As regards the soil amelioration, green manuring aids in reclamation of sodic soils.

10.3 Organic Compost/ Manure

Chemical fertilizers are used in crop husbandry to boost crop output in order to feed the growing population, however both chemical fertilizers and pesticides have a negative impact on the environment. Organic manures are made from plant and animal waste and are a significant byproduct for farming and related sectors. Organic manures are waste materials derived from plants or animals that contain nutrients that can be utilized to both meet crop needs and replenish soil nutrients.

10.3.1 Type of Organic Manures

Organic manures can be divided into bulky and concentrated categories based on their composition and nutrient concentration.

(A) Bulky Organic Manure: Although organic manure is bulky by nature, it does provide small amounts of plant nutrients. Many tons of manure are added to the soil since bulky organic manures have low levels of plant nutrients. Despite having a lower nutrient concentration, manure creates a soil ecology that is conducive for crop growth. Farmyard manure, green manure, green leaf manure, and rural/urban compost are examples of common bulky organic manure.

The following enabling characteristics make bulky organic manure favored.

i. These manures provide vital micronutrients in addition to macronutrients like nitrogen, phosphorous, and potassium

ii. The functioning of the soil ecosystem is indicative of interactions & interrelationships among the elements of the soil environment. The soil ecosystem's ecological integrity is maintained as a result of the bulky organic manure's promotion and enhancement of soil microbial activity. The soil microbiome increases the availability of nutrients.

iii. Beneficial soil physical and chemical features are made possible by the organic manures' enhancement of the biological qualities of the soil. The physical characteristics of the soil, such as its structure, porosity, and ability to hold water, are significantly enhanced by the addition of manure.

iv. Furthermore, applying manure to the soil improves its chemical characteristics, such as its cation exchange capacity.

v. Soil-borne fungus as well as additional parasitic organisms is subject to population control by a favorable soil microbiota.

(B) Concentrated Organic Manures-Concentrated organic manures are those that are found in nature and have a greater proportion of plant nutrients—such as nitrogen, phosphorus, and potash—than bulky organic manures. Cake oil that is edible and cake oil that is not edible are two categories of manures derived from plants. Sesamum, groundnut, and linseed cakes are examples of common edible oil cakes; neem, castor, and cotton seed cakes are examples of non-edible cakes.

Conversely, concentrated organic manures derived from animals include fish meal, bone meal, hoof meal, blood meal, poultry manure, etc.

(C) Farm Yard Manure: Farmers may easily obtain farmyard manure, also known as FYM, which is the conventional type of manure. It is the end result of the liquid and solid animal excrement that has been dried and preserved on a farm. In rural farms, part of the cattle manure is used as fuel. Farmyard manure is primarily made up of the decomposing mixture of leftover litter, dry feed, roughages, and animal waste from the cattle shed, such as dung and urine. The majority of the time, microbial activity, leaching, and volatilization cause the nutrients in manures to be lost during field storage. By using care and better composting techniques, the amount of nutrients lost can be reduced.A well-rotted FYM typically has 0.5% N, 0.25 $P2O5$, and 0.5% $K2O$ in it. These data allow us to predict that 112 kg of N, 56 kg of $P2O5$, and 112 kg of $K2O$ are supplied by an average dressing of 25 tonnes per hectare of farmyard manure. Since nitrogen acts slowly, the first crop often receives less than 30% of it. Roughly 75 percent of the potash and 60 to 70 percent of the phosphate are made available to the crop right once. The succeeding crop can use the remaining plant nutrients. We refer to this as a residual impact.

(D) Compost: Decomposed waste materials such as leaves, twigs, roots, stubble, bhusa, crop residue, and biodegradable kitchen trash are considered compost manures. Fertilizers and other nitrogenous materials like cow dung speed up the breakdown process. This waste is consumed by a vast number of soil microorganisms, which turn it into well-rotted manure. Put differently, compost might be thought of as well-rotten organic matter that has been obtained from waste. Farm compost can be made from waste materials from the farm, such as trash, straw, weed plants, etc. Composting can turn organic wastes or wastes originating from the biological, animal, or agro-industrial sectors into usable manure. Organic waste sources can be categorized as follows:

i. Agriculture: Weeds, etc., and crop leftovers (paddy, straw, sugarcane, etc.).
ii. Animal husbandry: chickens, pigs, goats, sheep, etc.
iii. Agro-industries include the sago industry, the sugar industry (pressmud), the coir industry (coir pith), and the industries that process fruits and vegetables.

iv. Municipal Activities: Market waste (vegetable, fruit, and flower markets), household and municipal solid garbage, etc.

According to percentage figures, agricultural compost typically contains the following nutrients: "0.5 percent N, 0.15 percent P2O5, and 0.5 percent K2O." The town compost that is made from waste materials such as dustbin waste, human waste, and street sweepings has an average of 1.4% N, 1% P2O5, and 1.4% K2 O in terms of nutrients. In order to prepare farm compost, trenches of 4.5 m to 5.0 m x 1.5 m to 2.0 m x 1.0 m to 2.0 m are typically dug, and wastes are layered inside of them. Cow dung slurry is spread on top of each layer to supply the bacteria needed for composting. Typically, the trenches are then filled with soil up to 0.5 meters above ground, then plastered to reduce nutrient loss and create an ideal environment for composting. When the compost was ready to be applied to the soil after six months, the C:N ratio would have decreased. Compost possesses the exceptional capacity to enhance the physical, nutritional, and biological qualities of soils as well as growing media. Composting has several advantages, including:

- Improving the physical characteristics of the soil, such as bulk density, porosity, and structure, which improves the root environment of plants.
- Improving water-holding capacity lowers water loss and leaching in sandy soils. It improves the infiltration of moisture and permeability of heavy soils, reducing erosion and runoff.
- Provides both macro- and micronutrients in diverse amounts.
- May inhibit or suppress some plant diseases that are carried in the soil.
- Provides substantial amounts of organic materials.
- Enhances soils and growth media's cation exchange capacity (CEC), enhancing their capability to retain nutrients for plant uptake.
- The microorganisms that are useful are added to growing media and soil.
- Raises and maintains the pH of soil.
- Able to bind and break down particular contaminants.

10.4 Biofertilizer

Live formulations of these advantageous microbes, known as biofertilizers, are ready-to-use and when applied to seeds, roots, or soil, they increase the availability of nutrients through their biological activity. Additionally, they support the development of soil health and microflora. Application results in improved plant growth, higher yields, improved soil fertility, and decreased pollution. Stated differently, biofertilizers are described as mixtures that comprise active or dormant cells of effective strains of microorganisms that aid in the uptake of nutrients by plants through interactions with the soil or rhizosphere when delivered via seed or soil. They augment the degree of nutrient availability in a form that is easily absorbed by plants.

They serve as an inexpensive and environmentally beneficial substitute for artificial fertilizers by providing plant nutrients. When utilized on a regular basis, biofertilizers boost yield and improve resilience to environmental challenges like insect and disease issues, severe heat, early frost, and drought. A biofertilizer is a broad population of a particular or group of advantageous microorganisms that improve soil productivity through fixing nitrogen from the atmosphere, solubilizing phosphorus from the soil, or inducing growth-promoting compounds in the soil to promote plant growth. In general, bio-fertilizers can be divided into two groups: phosphorus-mobilizing microorganisms and vesicular arbuscular mycorrhiza are examples of phosphorus-solubilizing microorganisms; and nitrogen-fixing organisms like Rhizobium, Azotobacter, Azospirillum, Acetobacter, Blue Green Algae, and Azolla. In recent times, commercial operations have identified fungal cultures such Pencillium citrinum as a manganese solubilizer, Thiobacillus species as a zinc and sulfur solubilizer, and Frateuria aurentia as a potash mobilizer.

10.5 Mycorrhiza and fertilizer applications

Mycorrhiza means fungus root, was first applied to fungus free associations described in 1985 by the German forest pathologist A.B. Frank. Mycorrhizae are mutualistic symbiotic association formed between many plants roots and certain fungi. There are 4 main mycorrhizae viz. ecto, vesicular arbuscular (VA), ericoid and orchidaceous. In Ectomycorrhiza, the fungus forms a compact mantle or sheath over the root surface and the hyphae grow out into the soil. These are generally found in forest trees including many gymnosperms (e.g. pines, spruce, fir, larch) and angiosperms (e.g. oak, beech, eucalyptus, poplar). The mycorrhizal hyphae assume at least partly the functions of root hairs. Pinus spp. showed better results with VAM as symbiont. The ectomycorrhizal fungi help the plants in phosphorus uptake through increased surface area of absorption, offer protection from some soil-borne plant pathogens and enhance rooting and survival of cuttings through production of growth hormones.

10.5.1 Importance in Agriculture

Mycorrhiza apart from providing nutrients to the plants also contributes to soil health and other benefits which include

- The threads of mycorrhizal fungi, or filaments, facilitate drought tolerance in the partner plant by improving the soil's water-holding ability.
- The fungi specifically exclude the passive absorption of toxic components that restrict the sensitivity of the partner plant to heavy metals, such as lead & cadmium.
- Mycorrhizal fungi degrade and absorb nutrients from primary rock surfaces at high latitudes, high altitudes and other rocky conditions.
- Mycorrhizal fungi can also protect plants both directly and by fostering plant vigour against pests, such as nematodes, and diseases.
- The fungi may shield their partner plants against high salt concentrations in saline soil.
- The filaments' outer walls produce gluey compounds that cause fine earth particles to clump together, forming soil structure and make the soil less susceptible to erosion.

In addition to plant growth promotion, by fixing more carbon in the vegetation, mycorrhizal fungi may also contribute directly or indirectly to the stabilization of soil carbon. First, the filaments of fungi have a portion rich in carbon that can remain for decades in the soil. Second, it provides the first step in transforming plant waste into stable soil carbon for other soil fungi.

10.5.2 Advantages of Mycorrhizal Application

- A single treatment can last for the whole lifetime of the plant.
- Minimizes fertilizer use, watering costs and plantation management costs.
- It is compatible with herbicides and insecticides that are commonly used.

- Mycorrhizal plants exploit nutrient sources in the soil at maximum making it a sustainable approach of cultivation and production systems while using the minimum of agrochemicals.
- Artificial inoculation with mycorrhizal fungi brings mycorrhiza to new planted plants and trees helping them in their establishment, growth and survival rate.

10.6 Plant Propagation

10.6.1 Micro plant propagation

It refers to propagation from small plant tissues using tissue culture method. In other words, plants are propagated from small plant tissues under aseptic conditions on synthetic nutrient media.

10.6.1.1 Technique of Micro Propagation: Micro propagation can be accomplished through four stages i.e. explant establishment, explant proliferation, in vitro rooting and acclimatization.

i. **Explant establishment:** Any part of a plant such as shoot tip, root tip, nodal segment etc used for culturing on synthetic nutrient media is termed as explant. Establishment of these tissues is done on basal media containing macro and micro nutrients, vitamins, amino acids and a source of carbohydrates. Most commonly, Murashige and Skoog (MS) media is used as basal media for raising most of tissue cultures.

ii. **Explant proliferation**: The “in vitro” established cultures are subsequently cultured on MS media supplemented with appropriate growth regulators. For instance, cytokinins like Benzyl Amino Purine (BAP) or Benzyl Adenine (BA) are most commonly used for shoot proliferation.

iii. **In vitro rooting**: The individual shoots are separated out of proliferated shoot cultures and then are cultured on MS media supplemented with suitable auxins for root induction. Most commonly, Indole Butyric Acid (IBA) or Naphthalene Acetic Acid (NAA) is used for in vitro root induction in the proliferated shoots.

iv. **Acclimatization**: The rooted plantlets are then acclimatized (hardened) before transfer to the field. Acclimatization is done by planting in vitro rooted plantlets in appropriate rooting media and by maintaining desired relative humidity during hardening.

10.6.2 Advantages of Micro Propagation

i. The rate of multiplication is much faster and quicker than the conventional methods of propagation.
ii. True-to-type plants can be produced through this method.
iii. Disease free plants can be produced, especially if meristem (0.1-0.5 mm tip of shoot) is the source tissue for multiplication.
iv. Year round production- As the uniform temperature and humidity is maintained in the incubation room throughout the year, tissue culture plants can be produced all the year round.
v. Easy exchange of germplasm- Using the technique of tissue culture propagation, germplasm can be easily carried across the counties.
vi. Saves time and space- Large number of plants can be produced in a very little space (as small as a culture vessel).
vii. Exhibit better quality and yield- Micropropagated plants come into bearing early and exhibit better yield and quality.

10.6.3 Disadvantages of Micro Propagation

1. Needs expertise and expensive set up for in vitro plant production.
2. All plant species/varieties cannot be propagated at will-some are difficult to propagate (recalcitrant).

Thus, this technique of propagation should only be used as supplemental technique for plant propagation, especially in case if it is not possible to conventionally propagate the plants.

10.6.3 Macro plant propagation

One relatively simple method that may be done in a shed or even in the field is macro-propagation. It includes of eliminating apical dominance to produce suckers from clean planting material. Two types of macro-propagation exist detached corm techniques that are carried out in a shed and field-based techniques that rely on whole or partial decapitation.

For macro-propagation, the starting material must be clean. There are numerous methods for obtaining clean beginning material:

- paring suckers
- treating them in hot or boiling water
- employing tissue culture plants
- chemically treating the suckers

10.6.4 Field Techniques

There are two methods of beheading. By eliminating the pseudostem's meristem, or active growing point, the two decapitation procedures encourage the formation of lateral buds. In the field, both methods promote sucker proliferation and sprouting. The pseudostem is rendered slightly perforated by false decapitation, which allows the meristem to be killed. After then, the foliage continues to be physiologically active for almost three months. The meristem is destroyed by completely decapitating the pseudostem.

10.6.5 Detached Corm Techniques

In this a greater number of seedlings that are produced as well as consistent seedling growth. Once growing in the field, seedlings derived from detached corm procedures also exhibit reduced susceptibility to stress. Techniques for detached corms consist of:

- whole corm
- split corm
- excised buds
- meristem-drilling
- PIF (plants issues de fragments) / plants resulting from stem fragments.

Summary

Agricultural production increased in the recent past increased due to technology intensive agricultural activity. Use of synthetic fertilizers is perhaps essential for growing fertilizer responsive crop varieties. Nevertheless, the environmental concerns associated with excessive use of synthetic fertilizer brought to the forefront the need for an alternative to synthetic fertilizer. Manures and biofertilizers are exceedingly important as they have potential to cater to the demands of agriculture and also maintenance of ecological integrity of soil ecosystem. We have studied in this unit about the role of manures and biofertilizers in augmenting agricultural production and benefits of using the same in agroecosystem. This can be summarised in the following,

Scientific underpinnings of manures and biofertilizers.Types of manures from the perspective of nutrient composition, and bulkiness of the manure.

Check Your Progress

1. What are bulky organic manure?
2. What are the Benefits of green manuring?
3. What are concentrated organic manure?
4. Write the advantages and disadvantages of micropropagation?
5. What is the Acclimatization technique?

Unit 11: Nursery Disease and their management

Unit Structure

11.0 Learning Objectives

After you have studying this unit, you should be able:

- To have basic understanding about diseases of nursery
- To understand control measures for nursery disease
- To know about the nursery pests

11.1 Introduction

The nursery stage of a forest is particularly vulnerable to disease. Large-scale afforestation initiatives and the industrial need for wood, which is scarce, have occurred recently. There is a need for planting stock because of large-scale plantation operations, for which nurseries have been set up. At the lowest feasible cost, there should be a sufficient quantity of plantable height seedling stock available. If a disease outbreak occurs in a nursery, the planting stock will be severely impacted, upsetting the plantation programmes. Therefore, it's essential to understand the various diseases that affect forest nurseries and how to manage them. Nursery stock can be severely damaged by pest and disease problems, which can cause both direct and indirect harm that could render the stock unsuitable for sale.

11.2 Diseases of nursery

Pests and environmental variables work together to create plant diseases. Insects or pathogens are more prone to attack plants that have already been weakened by environmental stress. For instance, weak trees are frequently attacked by wood-boring insects. Plants under stress take more hits and recover from injuries more slowly. Plant attractiveness in landscapes is improved by removing the stressor. Also, it makes them more resistant to insect infestations. Plant diseases can be caused by microbes such as bacteria, viruses, and fungi. In addition, there are a lot of helpful microbes. Soil organisms related to fungi and bacteria assist plants in fending off disease. Others target disease-causing nematodes and pathogens.

Three key factors are involved in the development of a plant disease. These are: (i) The pathogen, or organism that causes disease (ii) A plant host that is prone to the infection (iii) Environmental factors that encourage the growth of pathogens. The plant disease triangle (Fig. 1) illustrates this concept. All three sides of the plant disease triangle must be present for disease to occur. Remove one or more of the sides of the disease triangle to prevent plant diseases.

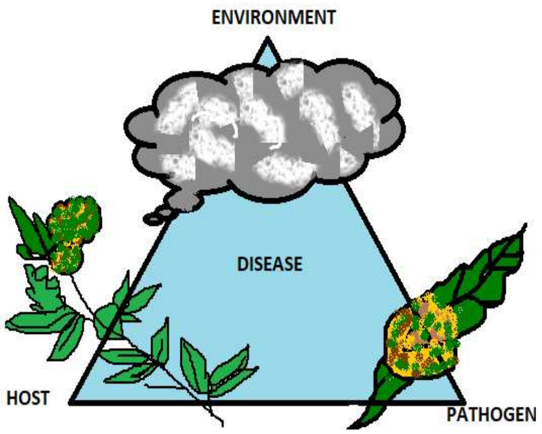

Fig1. Plant Disease triangle

Diseases of the underground parts of seedlings, known as root- and soil-borne diseases, can develop from the time of planting till lifting. It encompasses diseases of the root crown, taproot, lateral roots, tips, and pre- and post-emergence damping-off. One of the hardest disease conditions to diagnose is a root disease. The majority of root illnesses share a great deal of similarities with one another when it comes to their above-ground symptoms, as do those brought on by adverse soil conditions as high plough pan, excessive soil moisture, toxicity, and certain nutrient deficiencies. Most significant and prevalent soil- and root-borne diseases found in nurseries are as follows:

11.2.1 Damping-off

Damping-off is one of the first ailments that the nurseryman notices in his newly sowed beds (Figure 2). Many fungi induce damping-off, but the most prevalent ones are Phytophthora spp., Pythium spp., Fusarium spp., and Rhizoctonia solani. The disease, which can cause 15% or more mortality of viable seed, must be considered of critical importance. Only very young seedlings are attacked as the stems begin to form woody tissue (about 4 to 6 weeks following seed germination). The majority of conifer species are vulnerable, with the notable exception of junipers.

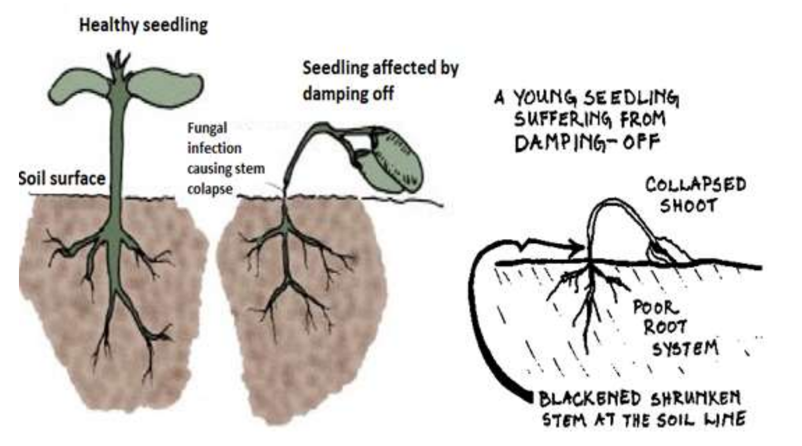

Figure 2: Damping off disease

Symptoms: Symptoms vary according to when the illness starts. Early attacks on the growing radical may destroy the seedling before it leaves the earth. Such pre-emergence damping-off may go unnoticed or be explained away as "poor seed." Post-emergence infection usually develops at or just below the ground level, leaving a water-soaked or necrotic patch on the succulent stem. In conifers, this tissue collapses, causing the seedling to become floppy and fall over. Hardwood seedlings, on the other hand, typically stand upright until wilting and breaking off. Damping-off is frequently confused with heat lesions, which appear as whitish sunken regions on the stem just above ground level. Heat lesions, on the other hand, are typically limited to one side of the stem.

Disease Development: The causative fungi are typically native to nursery soils. Some live on dead organic matter, while others exist as resting or dormant spores, waiting for a new host to infect (Figure 3). With each succeeding year of cropping, populations of these harmful funguses grow in nursery soils, increasing verage seedling losses. Any circumstance that lowers seedling development and vigour typically leads to an increase in infection. The illness is frequently more severe in nursery soils that are very damp. After just one or two rainy days, a stand of seemingly healthy seedlings can experience severe damping-off. Sideboards and shade frames that block ventilation may promote infection since the mattresses do not dry quickly. Temperature also affects development. Temperature influences the progression of this disease, depending on the fungus species involved. Some fungi, such as Pythium spp., thrive at high temperatures (27°-35°C). Nitrogen fertilizers administered before or during seedling susceptibility might also boost losses. Soil pH also causes considerable losses, which are typically greatest at high pH levels and minimal near pH 5.5.

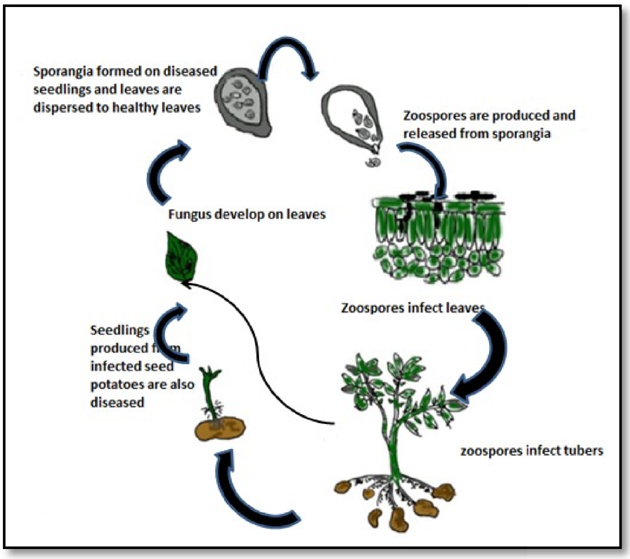

Figure 3: Disease development cycle

Control: Damping-off can be managed through cultural or chemical ways. Losses have generally been decreased by procedures that improve the rate and consistency of germination, as well as the speed with which seedlings grow in the early weeks. Soil moisture regulation may prevent fungal losses. Thiram, a seed-protecting fungicide, is occasionally useful but generally variable in minimising losses in conifer beds. Fungicides may limit the amount and rate of germination when temperatures are high. Soil treatment prior to seeding is possible. Inorganic acids have been shown to be effective in reducing pH in soils with pH levels ranging from 6 to 8. Drenching the soil with the fungicide captain is also useful, but once symptoms appear, it is usually too late for recovery. Soil fumigation before sowing can yield good results. Methyl bromide, chloropicrin, vorlex, or mixtures of these fumigants effectively suppress damping off and other soil-borne diseases in hardwood and pine seedlings.

11.2.2 Fusarium root disease

Fusarium root disease is one of the most common diseases affecting conifer seedlings around the world. Besides causing root disease, *F. oxysporum* and other *Fusarium* species are frequently responsible for damping-off in the early phases of seedling development.

Hosts and Damage: Most conifer seedlings are susceptible to Fusarium root disease. The pathogen exists in numerous host-specific forms. Only one specialized form has been described for conifer seedlings, *F. oxysporum fusarium* species pini. *F. oxysporum* attacks and kills a seedling's roots, resulting in chlorosis, stunting, wilting of the top, and eventual death. As with many root diseases, the primary impacts are (a) seedling mortality in the nursery bed, (b) an increase in the number of cull (stunted) seedlings and (c) greater losses after out planting due to weakened root systems.

Life History: The *F. oxysporum*, like other root disease fungi are inactive in the soil in the absence of a host and usually remain dormant in the form of chlamydospores (microscopic, thick-walled, single-celled resting spores). When a seedling root grows by a dormant chlamydospore, exudates from the root supply nutrients to the spore and stimulate its germination. The fungus grows over the root surface, penetrates between two epidermal cells, and spreads intracellular through the cortex. The fungus colonizes the cortex and the xylem elements of the infected seedling. Most pathogenic forms of *F. oxysporum* cause a vascular wilt, although many descriptions of the disease in conifers suggest it is a cortical rot. Either or both may be involved in seedling death. The microcondia are large, multicelled spores which may infect other roots, but which usually convert themselves into chlamydospores, when conditions become unfavorable and await next season's crop. The *Fusarium* fungus may be carried with the plant when it is outplanted and continue to attack the infected seedling roots, causing unexpectedly high transplant mortality. Although this fungus may continue activity for a year or two, the outplanted seedling may outgrow the infection if the infection is light.

Control measures: Cultural techniques have not been useful in managing this disease. Soil additives, which showed promise in preventing certain *Fusarium* diseases in agricultural crops, have yet to be proven useful in the forest nursery. In the current situation, the most effective technique of control is to fumigate the soil with methyl bromide, chloropicrin, or other soil fumigants before planting. Fumigation has been beneficial in various areas of North America.

11.3 Control measures

Insect pests are a major problem in natural forests, plantations and nurseries and the forester is required to prevent and control the damage done by them.

Principles of Prevention and control

The most significant aspect of pest management is early detection and timely reporting to exporters for advice. A control measure's action on the pest can be direct or indirect, preventive or remedial. The most crucial aspect of pest management is early detection and timely reporting to professionals for help. In terms of forest protection, control methods are:

(1) Silvicultural control

(2) Biological control

(3) Mechanical control

(4) Chemical control

It should be mentioned that it is impossible in practice to remove a forest insect infestation. The goal of artificial control, as opposed to natural control, is to limit the number of pests to a level where the damage caused by them is within financial tolerance. In other words, if the loss is viewed as an unavoidable consequence of forest management objectives, the pest may be regarded under economic control. Under economic control, it fluctuates much below the threshold at which it becomes problematic.

11.3.1 Silvicultural Control

By silvicultural control is understood the regulation of the abundance of a forest insect species by factors of silvicultural practice. Silvicultural practice may be designed and employed so economic control of an insect problem, but it acts independently of any goal on the part of the forest officials, and sometimes unrecognized by them. If a forester changes a mile insect into a pest by applying previously established silvicultural procedures, the pest can only be avoided from causing irreversible damage by actions of a similar order to those that created it.

Pure stands (management of forest composition, influencing food supply and quantity). (I) Pure stands offer the most favorable conditions for the multiplication of pests because the area gives the maximum number of food supply (ii) the pest in all phases has no trouble in locating food supply and breeding material (iii) an abundance of natural adversaries, such as parasites of nesting or insectivorous birds. Thus, even aged plantations or forests under the uniform system are vulnerable to insect infestations. All of the major pests of Indian forestry are most harmful in forests of this class; for example, (1) the behole borer of teak *Xyleutes ceramicus*, teak canker grub (*Dihamus cervinus*), defoliator (*Calopopla leavane*), the phassus borer (*Phassus rnalabaricus*), champaca bug (*Drastylus punetigera*), and teak defoliators (*Hapalia machaeralis* and *Hyblaea purerna*) are all plantation pests and rarely so in natural forests. The structure of natural and virgin forests is completely disrupted in a pure stand, resulting in insect outbreaks in such regions. In pure stands, it is critical to preserve natural forest strip regions.

Mixed forests

The value of mixtures in protecting the principal timber species in the crop lies in the following advantages

(1) Reduction in the quantity of food supply available to the pest in the area;

(2) varied food and suitable shelters are made available for parasites and predators that are maintained at a high level owing to the existence of alternate hosts;

(3) Insectivorous birds get a continued food supply throughout the year.

(4) Mechanical observation is offered to the dispersal crawing defoliators (larvae) that drop to the ground from crowns and try to reclimb the trees, and they die out of starvation, mechanical obstruction is also offered to the flying adult insects in finding the food plant of choice.

Thinning: Abrupt thinning at longer intervals is undesirable, gradual thinning at smaller intervals does not interfere with the natural balance between the pest, parasite and plant community.

Density: Density of the crop influences the physical conditions by modifying the intensity of light, evaporation, air, environment and fluctuations of temperature. All these factors indirectly affect insect life in forest.

Regeneration areas: Regeneration by small areas is advantageous since it restricts food supply of pests. Regeneration approaching natural process achieves immunity from insect damages. Artificial regeneration suffers more than natural regeneration.

Fire: The effects of fire can be considered from the aspect of burning and fire protection.

(1) Burning: Burning of refuse in clear felled areas prior to artificial stocking destroys all the insects and small animal life that are unable to fly or run at the time of burning. The result is that the area is cleared of pests and as well as all beneficial or harmless members of the community are exterminated. Controlled burning in high forest destroys many of the free living animals mice, lizards, etc. and kites, hawks later feed on their corpses; insects in the canopy or high up in the trunk drop to the flames. Under no ordinary circumstances is it wise to use ground fire as a remedial measure for an insect epidemic.

(2) Fire protection: The exclusion of fires from forests previously exposed to periodic burning has far reaching effects, i.e„ it permits tree growth in deciduous forests, fire-tender species, particularly the evergreens are protected and a forest occurs but scrub-growth protected thus invade forest trees. The direct effect of continuous fire protection on animals is marked by the increase and performance of animal populations and particularly of the natural enemies of insect pests.

11.3.2 Biological Control

In modern usage biological control means the employment of natural enemies and diseases of a pest for the purpose of maintaining economic control. It is not confined to the utilization of parasites only. In forestry biological controls are used in conjunction with the silvicuitural control and may be regarded as an extension of the same. In forestry tree biological methods may be utilized:

i. Mass production and release of selected parasites and predators as a regular annual operation.
ii. (Importation and Colonization of species that is not indigenous. This is a non-recurrent operation.
iii. The natural enemy complex of an indigenous pest is incomplete in a particular locality owing to the absence of certain efficient species of its parasites or predators.
iv. Improvement the environmental resistance to the pest by modification of plant community. Measures designed to increase the environmental resistance to a pest can only be used when the crop is grown on a long rotation as • in forestry (not applicable in agriculture)

11.3.3 Mechanical Control

In forestry, the following mechanical measures are tried:

i). Racking and compacting the humus to eliminate oviposition.
ii). Sticky bands to trap or work as barriers to insects climbing the trees (deodar defoliator. moth, shishann defoliator, salix defoliator etc.)
iii). Hand collection of egg masses, caterpillars, beetles, hagworms during hibernation.
iv). Traping sinking earthen pots flush with the ground in nurseries, light-trap, trap by baiting.
v). Flooding, burning, trenching, crickets in nursery, grass-hoppers etc.
vi). Burning and charring.

vii). Barking (against bark borers, salai and other serious sap and heartwood borers).

viii). Sack banding and pruning (loon and semul shoot borer, etc.)

ix). Repellants and attractants.

11.3.4 Chemical Control

Following are some of the chemical measures adopted:

i. **Wood Borers in storage:** Debarking, prophylactic insecticides DDT, BHC etc. preservation under pressure with creosote and others, existing infection by sterilization.
ii. **Termites:** DDT, BHC to kill colony in mounds, soil poisoning to keep off termites, use of resistant varieties of timber that are naturally resistant, special measurement in building etc.
iii. **Tree Poisoning:** Sodium arsenite, ammonium sulphanate, sodium silicoflouride etc in paste form.
iv. **Defoliators, sapsuckers:** Spraying and dusting contact or stomach insecticides.
v. **Stored products:** Fumigation with carbon disulphide dischlorobenzene, etc.
vi. **Sprays:** Crude oil emulsion, kerosene oil emulsion, nicotine solution, DDT, BHC, soap solution (contact poisons). Deem leaf extract, paris green, arsenates (stomach poisons).
vii. **Repellents:** Derdeaux mixture, mosquito ointment.
viii. **Fumigants:** Carbon disulphide, calcium cyanide, naphathalene, dichlorobenzene.
ix. **Wood preservatives:** Creosote (Standard wood preservative) fuel oil, boric acid, sodium fluosilicate, zinc chloride.
x. **Sticky bands:** Tar-pitch oil (coaltar, pitch, dry soap, castor oil, earth, in the proportion - 37.5 : 7.5 : 10 : 12).

11.4 Chemicals used for disease control

11.4.1 Chemical Control

Certain chemicals are employed as fumigants, sterilants, or disinfectants to kill pathogenic organisms before planting, even though they are hazardous to the majority of living things. Less hazardous pesticides can be used to control diseases that might otherwise cause large losses in horticultural or agricultural crops. Depending on the target species, these substances can be classified as fungicides, bactericides (also known as antibiotics), or nematicides. An "ideal" chemical control agent must be effective at concentrations that do not damage plants when applied to plant structures or growth phases. It should not trigger allergic reactions and should present the least amount of danger to both humans and animals. Long-term negative effects on the normal soil and plant microbiome should be minimal. Some chemicals commonly used to control plant diseases are listed in table 1.

Table 1: Some chemicals commonly used to control plant diseases

CHEMICAL AND USE	RELATIVE TOXICITY	
	ORAL	DERMAL
SEED TREATMENTS (ALL FUNGICIDES)		
Chloraneb	Low	Low
Dichlone	Low	High
Thiram	Moderate	High
Carboxin (systemic and therapeutic)	Low	Low
SOIL TREATMENTS		
Methyl bromide[b] (general pesticide)	Very high	Very high
PCNB (fungicide)	Low	Moderate
SMDC [vapam] (fungicide, nematicide)	Moderate	Moderate
MIT ["Vorlex"] (fungicide, nematicide)	Moderate	Moderate
D-D mixture (nematicide)	Moderate	Low
PLANT-PROTECTIVE TREATMENTS		
Copper compounds (fungicides, bactericides)	Moderate	Low
Sulfur (fungicide)	Low	Moderate
Maneb (fungicide)	Very low	Low
Zineb (fungicide)	Very low	Low
Captan (fungicide)	Very low	Very low

Dinocap (fungicide for powdery mildews)	Low	Low
Streptomycin (bactericidal antibiotic)	Very low	Low
Cyclohexamide[b] (fungicidal antibiotic)	Very high	Very high
Benomyl (protective and therapeutic fungicide)	Very low	Very low

It is predicted to have minimal detrimental long-term effects on normal soil and plant microbiota. The agricultural product should be persistent and chemically stable enough to meet harvesting needs, but not so persistent as to cause issues with residue management. It is improbable that the disease or pathogens will rapidly develop chemical resistance. It should have characteristics that make accurate and effective application to the plant or crop material possible. It should be compatible with other biocidal agent formulations both physically and chemically. It should have a long shelf life, which allows it to be stored in ordinary climates for extended periods of time without losing any of its effectiveness. Including all of these needs in a single molecule is inherently difficult. Additionally, The chemical control of plant diseases is classified in three categories: seed treatments, soil treatments, and protective sprays and dusts.

11.4.2 Seed Treatments

Plant diseases in, on, and surrounding planted seed may be effectively controlled by chemical treatments of the seed. Treatment for seeds is classified as eradicative when it eliminates fungal spores that contaminate seed surfaces, protective when it stops soil-borne fungus from penetrating seedling stems, and therapeutic when it eliminates bacteria or fungi that infect embryos, cotyledons, or endosperms beneath the seed coat. Typically, certified seed receives the appropriate treatment to prevent certain diseases. There are two kinds of seed treatment: chemical and physical.

i) . **Physical treatments**: It include hot-water treatment, solar-heat treatment (loose smut of wheat), and the like.

ii). **Chemical treatments:** It involves applying bactericides and fungicides. There are various ways to apply these fungicides to seed. One technique uses basic seed treaters to treat the seed in tiny batches. Using the seed-dip method, fungicide suspension is made in water, usually at field rates, and the seed is dipped in it for a predetermined amount of time. The majority of eradicative and protective compounds have a wide spectrum of fungicidal activity; they are effective against most seed-infesting and seedling-blight fungi. The oxathiins (carboxin, DMOC) used to destroy embryo infecting smuts of cereal grains have little effect on other organisms. However, a particular agricultural plant species' disease is typically best controlled by using a particular seed treatment chemical. Thiram, chloraneb, dichlone, dexon, and captan are examples of organic chemicals that are now often utilized as seed treatments for protection and eradication.

11.4.3 Soil Treatments

Soil-borne plant pathogens rapidly expand in population as soils are cropped continuously, eventually reaching levels that render contaminated soils unfit for agricultural production. Chemical treatments of soil that eliminate plant pathogens enable the quick recovery of infected soils for agricultural use. To control nematode-induced diseases, field soils are chemically treated prior to planting, and seedbed and greenhouse soils are fumigated (with methyl bromide, for example) to eliminate weeds, insects, and plant pathogens. Soil-treatment chemicals for fungal control are typically applied in the field to treat furrows. Formaldehyde is efficient against sclerotia fungus, which cause seedling blights, stem rots, and root rots in many field crops. Soil treatments used at the time of planting are most effective against parasitic infestations that occur early in the growing season.

11.4.4 Protective sprays and dust

Protective fungicides inhibit germination, growth, and penetration. To utilize protective fungicides efficiently, the farmer must not only choose the right fungicide for the purpose, but also apply it in the proper amount, timing, and manner. Too little fungicide fails to suppress disease, while too much might be hazardous to the plants being protected. The timing of applications is also essential.

11.5 Nursery pests in the nursery

Forest nurseries are attacked by the following insect pests in different parts of India and its neighboring countries:

1. The cutworm, *Agrotis ipsilon* Hufn. (Lepidoptera: Noctuidae)

Cutworms are especially harmful to conifers such as deodar and pine trees during the months of March and April. It has been found to injure newly emerged young Eucalyptus seedlings in Central India.

Fig. 4. Larvae of Cutworm

This insect's fertilized female moth lays approximately 2000 eggs in little clusters on weeds, stones, hurrlugs, and other plants. The larvae (Fig. 4), sometimes known as cutworms, hatch within two to six days and consume dried leaves and green vegetation. These cutworms dig 30 to 75 mm deep into the ground to hide during the day.

Fig. 5. The cutworm, *Agrotis ipsilon* (Moth) Source: https://commons.wikimedia.org/wiki/File:Agrotis_ipsilon_female.jpg

At night, the larvae emerge from their tunnels and feed on the seedlings by cutting through the stem at ground level. They rarely climb and cut down too huge plants. The fully grown larva is smooth, with small hairs, and measures approximately 40 mm in length. When disturbed, it curls into a C shape. The larval period varies between 20 and 35 days. The fully grown larva creates a pupal chamber in soil to undergo pupation. The pupal phase lasts from ten to thirty days. The complete life cycle lasts 5 to 9 weeks, with two generations in cold weather on the plains (Fig 5). Euxoa segetum Schiff. is another species of cutworm that harms nursery plants.

Control measures:

i. The edges of the nursery beds, surroundings, transplant beds etc. should be kept clean from the weed. It prevents the egg lying of the moths.

ii. Collecting and destroying larvae during digging helps limit the population of cutworms.

iii. Flooding or irrigation in nurseries causes cutworms to emerge from their tunnels, allowing for collection.

iv. Coating seed beds with wood ash helps prevent cutworms from feeding on nursery seedlings.

v. Chaudhury and Mallik (1981) found that using chlordane 5%, heptachlor 5%, aldrin 5%, endosulfan 4%, and quinalphos 1.5% at a rate of 2.5 Kg a.i./ha effectively combats cutworms.

vi. According to Pareek and Noor (1978), adding 5% heptachlor dust to soil before seeding is equally effective.

vii. A bait formulation (bran, sugar, and water) containing 0.25 percent quinalphos (Ekalux) effectively controls this pest.

2. White grubs: (Coleoptera: Scarabaeidae, Melolonthidae and Rutelidae):

Figure 6: White grub
Source: https://www.flickr.com/photos/andreaskay/10618418336

Cockchafer beetle larvae are called white grubs. These grubs eat the roots and rootlets of seedlings in forest nurseries (Fig 6). The beetles emerge from the earth at the start of the monsoon. After mating, they lay white oval eggs in the earth. After a few days of egg development, the hatching occurs. The newly hatched grubs eat on semi-decomposed cow manure, seedling leaves, roots, rootlets, and so on. These grubs undergo moultings and eventually mature to full-grown final instars in September, e.g., *Holotrichia* spp. in Madhya Pradesh, Orissa, and Maharashtra, or in April, e.g., *Hiliyotrogus holosericea* Redt. (Gupta et al., 1976).

After a pupal stage of 13 to 30 days, the beetles emerge from the soil shortly after the first monsoon rainfall (Gupta et al, 1976). All white grub species are monogenetic. *Hiliyotrogus holosericea* Redt., *Anomala rufiventris* Redt., *Lachnosterna longipennis* Blanchard, and *Melolontha* spp. damage the roots and rootlets of *Cedrus deodara*, *Pinus* spp., *Quercus leucotrichophora*, etc. in high altitudes of north India, whereas *Holotrichia* (Lachnosterna) c*onsanguinea* Blanchard feeds on sal. The grubs of H. insularis Brenke and H. serrata Fab. have been identified as major pests in teak nurseries in Madhya Pradesh, Maharashtra, and Orissa. *Anomala dalbergiae* arrows have also been observed on shisham (Beeson, 1941).

Control Measures:

i. The beetle prefers sandy soil for egg laying and hence use of sandy soil should be avoided for raising nursery seedlings (Joshi and Namdeo, 1990)

ii. Weeding and preparation of the nursery beds should not be done during monsoon.

iii. Ploughing and digging of soil in winter facilitate in collection and destruction of white grubs.

iv. Mixing of aldrin, BHC, chlordane, DDT and heptachlor 5 % dust, thimet 10 G and disyston 5 G, each @ 30 to 40 Kg/ha in nursery beds in July kill the freshly hatched grubs of A. rufiventris Redt. (Gupta and Rai, 1984), Holotrichia consanguinea Blanch (Patel et al., 1967; Prasad, 1975) and H. holosericea (Gupta et a1.,1976).

v. Thimet or phorate 10 G granules @ 200 gm/nursery bed (size 10 x 1 M) should be mixed in soil in furrows during the fore half of July (Vaishampayan and Bhandari, 1981).

3. Termites

White ants and termites are also major nursery pests (Fig 7). Termites are social insects, living in colonies, subterranean in habit and requiring soil moisture and avoiding light throughout their life. They consume the underground rhizomes, roots, and stems of forest tree species. *Odontotermes* species consume branch cuttings of *Populus deltoides* in Assam (Joshi et al., 1984) and Eucalyptus seedlings in Madhya Pradesh and Uttar Pradesh (Ann. 1987).

In the colony can be found a large number of sub groups, each performing special duties for the colony, and the commonest of these are king, queen, soldiers and workers; the royal pair king and queen live in a royal mud cell underground, the workers work for the colony (bring food, construct nest etc.) and soldiers guard the colony. The commonest nest of termite visible above ground is the termite mound, which is spectacular and is only a part of the nest, the main colony being underground. The young termites that hatch out from eggs, called nymphs, are specially fed on fungus that is grown in a fungus garden in special beds called fungus combs. Later they are allowed to graze along with other termites and they chiefly consume cellulosic materials as food which no other insect group has the power to digest. Termites have interesting habit of licking each other can transmit any kind of food, be it their normal food or a poison by accident from one termite to another. Wood in buildings in forests lying on ground, in mils, depots, bark of living trees, young plants and their roots, cloth, papers etc. are eaten by termites.

Figure 7: Termites
Source:
https://commons.wikimedia.org/wiki/File:CSIRO_ScienceImage_3639_Mastotermes_darwiniensis_Giant_Northe

Control measures:

i. The red ants collected from field if released on nursery beds, destroy the termites.

ii. Aldrin 5 percent dust, @ 40 to 60 Kg/ha or phorate (thimet) 10G @ 40 Kg/ha if mixed thoroughly in soil, kills the termites.

iii. Application of 0.1 per cent water emulsion of aldrin 30 EC @ 50 Lt per bed (10 x 1 M) is said to be completely effective to kill termites damaging the germinating seedlings of *Albizia lebbek* and Eucalyptus FRI-4 (Ann.1987).

iv. When young plants are observed to be drying off in seed beds and in nurseries, upper layer of soils should be turned over and searched for termites. The dying may also be due to cockchafters, cutworms, crickets, etc or to drought or to damping off. If termites are responsible for dying it is best to water the lines with weak crude oil emulsion or concentrated extract of tobacco leaves.

4. Grasshoppers:

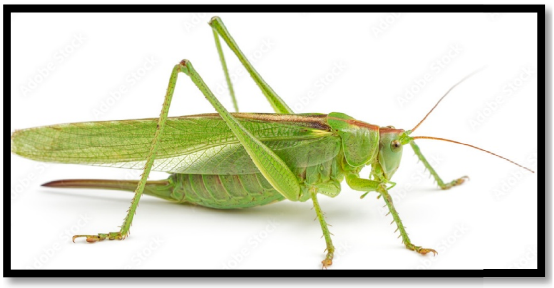

Fig. 8. Grasshopper
Source: https://stock.adobe.com/in/search?k=grass.grasshopper&asset_id=90493549

Grasshoppers are polyphagous insects. They feed on new shoots and leaves in nurseries. The adults lay eggs in the dirt, and the young nymphs emerge to feed on the foliage. As the nymphs mature, they become more voracious feeders of leaf mare, causing the seedlings to die. The life cycle of these insects ranges from one to three generations per year. Hieroglyphus species defoliates bamboo and teak seedlings, whereas Chrotogonus species and Oedaleus abruptus Thunberg defoliate Pinus carabea and Poocarpa seedlings (Browne, 1968; Singh and al., 1982; Khan et al. 1985).

Control measures:

i. Regular weeding in and around the nursery, helps to reduce the incidence of grasshoppers.

ii. Spraying of BHC or phosphamidon 0.05 percent can kill most of the young and old grasshoppers (Joshi and Namdeo, 1990).

11.6 Minor nursery pests in the nursery

Some of the minor nursery pests are discussed below:

11.6.1 Crickets

Figure 9: Female Cricket
Source: https://en.m.wikipedia.org/wiki/File:Tarbins_portent_060616-07604_cromb.JPG

1. Tarbinskiellus (Brachytrypes) portentosus (Licht) (Orthoptera:Gryllidae): This huge, blackish-brown insect is over 50 mm long and has large antennae (Fig. 9). It lives in a deep subsurface tunnel that opens to the surface in a giant noticeable hole surrounded by expelled mud. During

September and October, the insect lays eggs at the bottom of the tunnel. The newly hatched nymphs remain in the parental house for a few days before dispersing. The young crickets dig new tunnels, which become longer and more remified as the bug matures. Adult crickets mature over a few months, often between May and July. Adult crickets spend their entire lives in the same tube. It emerges at night to mate and eat on young seedlings. The young seedlings and the pieces of the foliage are dragged into its tunnel for feeding. It is a pest of *Casuarina equisetifolia*, *Dalbergia sissoo*, *Eucaluptus* species and *Tectona grandis*.

Control measures:

i. Growing ragi (Eleusine coracana) around Casuarina beds diverts the cricket's attention away from the Casuarina seedlings.
ii. Pumpkin pieces attract crickets and can be used as a trap.
iii. Poison baits (Paris green 3 or 4 parts, flour 100 parts, and gur 1 part, mixed into a dry powder) sprinkled along the nursery's perimeter are effective at killing these crickets (Beeson, 1941).
iv. Flooding the tunnels with water and then applying kerosine leads insects to emerge, which can be destroyed mechanically.

2. The mole cricket, *Gryllotalpa africana* Palisot B. (Orthoptera: Gryllidae): It is a light-green, 30-mm subterranean bug that lives in burrows in light loamy soil (fig. 10). It can be found throughout India and Pakistan's plains and lower hills. Its nymphs and adults eat seedlings of *Bischofia javanika*, *Cinnamomum cecidodaphne*, and other agricultural crops. *G. africana palisot B.* adults construct an earthen cell about the size of a hen's egg at the end of the tunnel in May and June. The female lays up to 50 eggs in a cluster in the earthorn cell. The eggs hatch after 3 or 4 weeks of incubation. The young nymphs remain with their mother for a few days before dispersing. They burrow in

Fig. 10: Mole Cricket
Source: https://commons.wikimedia.org/wiki/File:Mole_Cricket_%28Gryllotalpa_africana%29_%2816643378886%29.jpg

the soil, go through three to four moults, and then hibernate for the rest of the year in colder climates. Thus, it has one generation per year. In Warner locations, however, it completes two or more generations per year.

Control measures:

i. Mole crickets can be driven out from their tunnels by pouring water mixed with a little amount of kerosine into the freshly made tunnels.

ii. In irrigated areas, flooding of water helps to coming out of the mole crickets from their tunnels. They can be collected and killed mechanically.

iii. Application of aldrin 5 percent dust or BHC 10 percent dust @ 25 Kg/ha in soil is also said to be effective against these crickets (Grangwar and Roy, 1985).

11.6.2 The borers

1. Semul shoot borer, *Tonica niviferana* Walk. (Lepidoptera: Oecophoridae): Its medium-sized moths lay eggs singly in the leaf axils of new semul stems. After hatching, the tiny larva burrows into the new shoots at a leaf axil, protected by a silk thread web. As the larva matures, it excavates a tunnel along the heart of the shoot or fully hollows it out, killing a stem all the way down to the old wood from the previous year. The tunnel is still filled with black larval excreta as well as particles of frass, gum, and other materials. Some frass is also discharged through the ejection hole, which is blackish or dark brown in appearance and plainly visible from a distance.The immature larva of this pest is yellowish brown, but subsequently turns orange yellow with black spots dorsally. After reaching a length of around 40 mm, the larva exits the tunnel and pupates on leaves, stems, and other plant parts. The pupal phase lasts 1 to 2 weeks. It has two generations per year.

Control measures:

i. Collection and destruction of the pupae on bark and leaves etc. in March to May, and in July to August in one year old sapling should be done.

ii. Pruning of the attacked coppice shoots of semul during the later parts of rainy season and inspection again during the cold months for later attack should be done.

iii. Sevidol granules @ 6 gms/sapling is highly effective to control this borer in 1 to 3 years old plantations (Singh et al., 1981).

2. The borer, Zeuzera coffeae Neitner (Lepidoptera:Cossidae): In the spring, this medium-sized, white moth with numerous black markings and streaks on its body and wings lays oval, reddish-yellow eggs on the bark of short stems or branches. After approximately ten days, the hatching occurs. The newly hatched larvae create little silken shelters on the stem. After a few days, the larvae emerge and hang themselves using delicate silk threads. The wind then transports these larvae across a large distance. Soon after receiving a host plant like *Casuarina equisetifolia, Chikrassia tabularis, Citrus spp., Coffea robusta, Grevillea robusta, Lagerstroemia speciosa, Melia azedarach, Phyllanthus emblica, Populus deltoides, Psidium guajava, Santalum album, Schleichera trijuga, Tectona grandis, Toona ciliata, Terminalia belerica* and *Thea chinesis* etc. (Beeson 1941; Joshi et al., 1984), these larvae start boring the young shoots, branches etc. and finally form long tunnels in the pith of the shoots. The larva ejects a tiny yellow wooden grass from its entrance pore. The full-grown larva is pink, robust, and smooth, measuring approximately 50 mm in length. Pupation happens in a large pupal tunnel. The object pupa is slightly elongated and reddish brown in hue. The imago is revealed by removing the shoot's loose, thin outer bark. It produces two generations each year (Joshi et al. 1984).

Control measures:

i. To combat this borer, it is recommended to sow or plant seedlings densely and thin out drilled saplings.
ii. Injecting dichloros into the entrance hole can eliminate the borer within the tunnel.

Summary

The nursery stage of a forest is particularly vulnerable to disease. Large-scale afforestation initiatives and the industrial need for wood, which is scarce, have occurred recently. Nursery stock can be severely damaged by pest and disease problems, which can cause both direct and indirect harm that could render the stock unsuitable for sale. Pests and environmental variables work together to create plant diseases. Insects or pathogens are more prone to attack plants that have already been weakened by environmental stress. Patogen, plant host and environmental involved in the development of a plant disease. Most significant and prevalent soil- and root-borne diseases found in nurseries are damping off *fusarium* root disease. Insect pests are a major problem in natural forests, plantations and nurseries and the forester is required to prevent and control the damage done by them. The most significant aspect of pest management is early detection and timely reporting to exporters for advice. A control measure's action on the pest can be direct or indirect, preventive or remedial. In terms of forest protection silvicultural, Biological, mechanical and chemical control methods are used for protecting forest nurseries. Forest nurseries are attacked by some of the major insect pests i.e. Cutworm, White grubs, Termites, Grasshoppers and minor insect pests i.e. crickets and borers in different parts of India and its neighboring countries.

Terminal Question

1. What do you understand by nursery disease? Discuss damping off disease in detail.
2. Discuss Fusarium root disease in detail.
3. Discuss Principles of Prevention and control of disease.
4. Discuss how plant diseases are controlled by the use of chemicals.
5. Explain various Nursery pests in detail.

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Unit 12: Protection Measure

Unit Structure

12.0 Learning Objectives

After completing this unit you shall be able to:

- Define protection measure in nursery
- Explain nursery disease and their management
- Explain nursery pests and their management
- Explain different control measures

12.1 Introduction

Learners, in the previous units you have studied the nursery, its function, establishment, kinds of nurseries, tools used in nurseries, nursery administration, tools or equipment used in nurseries, propagation techniques, etc. You now have a fundamental understanding of nurseries. Plants produced in nurseries require special attention to ensure their proper growth, development, and output. In order to understand about care or prevention and protection, the current unit deals with nursery protection measures, which covers how to keep the nursery safe from bad weather, disease, insects and general control measures, etc.

12.2 Protection Measure in Nursery

Climate records from the past and present should be assessed after closely observing the site's characteristics of the nursery. Plants cultivated in nurseries require special attention and precautions in order to ensure growth and development of the seedlings. It is necessary to take prompt and efficient precautions against unfavorable weather conditions, diseases, insects and pests. The following operations in the nursery must be carried out to ensure the development of high-quality seedlings:

- **Shading:** Unfavorable weather conditions i.e., high temperature, heavy rainfall, wind and frost etc. can affects the nursery crops. It is important to shield recently developed seedlings from bad weather conditions. Polythene sheets or shade-nets can be used to provide shade and prevention from such weather conditions.

- **Thinning:** In order to ensure that the plants receive enough light and air, it is essential to keep the plant density in rows. Weak, infected, or injured plants are removed throughout this phase for the better growth and development of healthy seedlings.

- **Watering**: A small can should be used to properly water nursery beds. Watering needs to be done based on each plant's specific requirements after the plants have been established.

- **Weeding:** The removal of any undesired plants, or weeds, from the nursery is referred to as weeding. Because weeds keep the primary plants from competing with them for nutrients, sunlight, water, and air, regular weed removal promotes the growth and development of seedlings. Insect pests and microbes that spread illness also use it as a secondary host. Weeds must therefore be kept out from the nursery area. The most popular methods for removal of weeds are hand weeding and harvesting. Prior to emergence herbicides can also be applied right after seed is sown to eradicate a huge variety of weed species.

- **Hardening of seedlings:** Before being planted in the main field, seedlings need to be strengthened out or acclimated, in some shade so they can withstand the severe open climate. Before transferring seedlings into an open field, hardening is typically accomplished by introducing them to progressively increasing temperatures. Avoiding over-hardening the seedlings is necessary.

- **Staking:** In order prevent plants from bending or lodging, stakes are used to support their straight growth. This is carried out while the plants are still quite short. The weight of the stems when in bloom also prevents the plants from being blown over by wind and rain. Potted plants, grafted plants, and budded plants can all benefit from it. Plants that are staked most frequently are bamboos. Other than this, the branches of shrubs and trees, i.e., Neem, Subabool, Phalsa, *Eucalyptus*, etc., can also be used for this purpose.

- **De-shooting:** The process of eliminating all side shoots that emerge from a plant's base is called de-shooting. Redirecting a plant's energy towards the growth of its buds or shoots is the primary goal of de-shooting.

- **Disbudding:** When a big size flower is wanted on a plant, such a dahlia, the process of disbudding involves removing the flower buds. Retained buds develop more vigorously and huge flowers because the energy saved by disbudding is directed towards their growth. With huge flower varieties, it is typically followed. To get longer stalks with bigger blooms, flowers are disbudded.

- **Pinching:** As in the case of chrysanthemums, it refers to the removal of vegetative buds' developing tips in order to encourage bushy growth, greater lateral development, and early flowering. It involves trimming the plants' 3-5 cm growth tips when they are 8–10 cm tall, or roughly one month old. Three weeks or so pass after the initial pinching before the second one occurs. In carnations and marigolds, pinching is also common.

- **Pruning:** Pruning is the deliberate elimination of twigs, branches, shoots, limbs, or roots from plants. Pruning is done to make plants have greater advantages.

12.3 Preventive Measures for Nursery Disease

(i). Damping-off: Nursery plants are vulnerable to this common and deadly disease, which may even result in dying. Fungi including Pythium, Phytopthora, Rhizoctonia, and Fusarium are the cause of damping-off, a pre-emergence disease that affects seedlings. Generally at the time of seed germination, these fungi attack. Girdling occurs in around of the seedlings' bases in this disease, and the diseased seedlings collapse as a result of rotting in the collar area. High soil surface moisture content and humidity, along with dark and hot weather, are favourable conditions for damping-off when it comes to dense planting. Maintaining a dry soil surface is one of the finest preventive measures since it contributes to a reduction in planting density and helps thin out the seedlings, improving aeration. Additional techniques include treating the nursery bed with formalin at a rate of 2% for soil sterilisation or solarization, soaking it in copper oxychloride at a rate of 2 g/l, or treating the seeds at a rate of 3 g/kg for thiram or carbendazim.

(ii). Wilt: Plants frequently have a faded and discoloured appearance. Leaves turned yellow.

(iii).Leaf spot: Leaves frequently have tiny to large black or brown dots on them.

The symptoms of seedling stress, including as rust, powdery mildew, damping off, wilt, and root rot, are brought on by pathogen infection and cause the growth of seedlings to be slowed. These infections can spread by seed, the soil, or the air. The establishment of nurseries on freshly cleared land rarely attracts parasitic organisms. Seedlings with slow growth are usually the result of overwatering, planting them in shaded regions, or losing soil richness.

Pre-treating seeds with fungicide, such as Captan, can suppress the disease and serve as a preventive strategy by sterilising the nursery mixture. Fungicide can be applied in accordance with the identification of the unintentional pathogen by the expression of symptoms, should the disease emerge. Some common nursery diseases were identified in Table 9, along with prevention strategies.

Table 9. Some common nursery diseases and their control measures

Disease	Affected Seedling Species	Control Measures
Wilt, Root Rot, Collar Rot	Shisham, Neem, *Casuarina, Eucalyptus,* Tomato	Drenching the soil with Copper oxychloride @ 2g/l or Carbendazim @ 2g/l or by applying Trichoderma harzianum.
Leaf Spot	*Eucalyptus,* Pomegranate	Spraying mancozeb @ 3g/l or Dithane M 45 or Fytolan 0.2% or Copper Oxychloride 0.2 %
Leaf Rust	Teak, Shisham, Ber	Spraying 0.2% Zineb Spraying 0.2% Wetable sulfer
Leaf Blight	Neem, *Eucalyptus*	Spraying Carbendazim 0.2%
Powdery Mildew	Teak, Neem, *Casuarina*	Spraying 0.2% Dithane Z-78 or Bordeaux mixture 0.1%

The Management of Integrated Nursery Diseases

- Selecting relatively healthy seeds or propagules for the formation of seedlings
- Mixture of 0.2% carbendazim, methyl thiophanate, benomyl, and thiram in the seed dressing
- Sowing/planting in clean, fumigated, and sterilized beds with sufficient moisture
- Using sterilized cutting tools, cutters and budding knife for grafting and budding
- Transplanting a seedling after putting it in a 0.02% carbendazim solution for three to five minutes.
- Maintenance of healthy planting materials by adequate sunlight, watering, and cleanliness
- Regularly monitoring the health of seedlings and eliminating contaminated stock
- Foliar spraying of 0.2% Dithane M-45 and Carbendazim at regular intervals

12.4 Nursery Pests and their Management

Nursery plants are fragile and vulnerable to damage caused by a variety of insects. The list of insect pests that infect nursery plants is provided in Table 2.

Table 2. Common insect-pests in nursery and their control measures

Insects	Characteristics or symptoms	Control
Aphids	Small green, brown or black sap-sucking insects, which secrete honey dew that attract ants and develop sooty mould	Dimethoate 2 ml/l Neem oil 4–5 ml/l
Thrips	Tiny black or yellow coloured sap-sucking insects, which infest young portions of plants and flowers	Dimethoate 2 ml/l Neem oil 4–5 ml/l
Scales	Small immobile sucking insects that are covered by wax mainly infesting the stems of plants	Dimethoate 2 ml/l
Mealy bugs	Small sucking pests covered by white filamentous hair	Chlorpyriphos 20 EC @ 2.5 ml/l 5% Malathion dust @ 25 kg/ha
Mites	Microscopic insects on the under surface of leaves producing webs and galls	Dicofol 18.5 EC @ 2.5 ml/l Wettable sulphur @ 5 g/l
Leaf miner	Leaf mining insect that produces serpentine (snake-like) white shining lines on leaves	Triazophos 0.25 ml/l
Termites	Tiny white ants that mainly infest dead parts of the plant and stay underground	Chlorpyrifos 0.3% (active ingredient) emulsion

These insect pests are categorized into three groups: major nursery pests (white grubs, cutworms, termites, and crickets), minor nursery pests (defoliators, sapsuckers, grasshoppers) and non-insect pests (nematodes and vertebrate pests). In general, improved nursery hygiene, the use of appropriate cultural techniques, and the proper application of chemical and biological pesticides only when necessary can reduce the impact caused by insects.

(i). White Grubs: While the larval stage of the grub feeds on roots during the monsoon season, the adult white grubs eat leaves. It is a major problem in the states of Tamil Nadu, Gujarat, Maharashtra, Madhya Pradesh, Teak, and Mango. Some preventative methods against white grub attacks include deep ploughing, solarizing the soil, poisoning, and applying light traps. One bed can be sprayed with 200 g of phorate or 50 ml of chloropyriphos diluted in 50 ml of water. Controlling the adult population can also be aided by foliar spraying host trees in the nursery area with 0.05% monocrotophos or 0.03% quinalphos.

(ii). Cutworms: It is a feeder of young leaves and quickly causes damage to the young seedlings following germination. Cutworms preferred seedlings from species such as

Pine, Cedar, Mango, Sapota, and *Casuarina*. Some preventive techniques for avoiding cutworm damages are flooding of nursery sites and the gathering of cutworms following heavy rains. To control the insect, spray the seed bed with a mixture of quicklime and ash or 1.5% quinalphos.

(iii). Termite: They harm seedlings through a number of methods, including primary assault (destroying the tap root), secondary attack (attacking again after a draught, infections, etc.), and complementary attack. As a result of their damage, the seedlings become weaker and more vulnerable to following pest and disease attacks. By maintaining the nursery free of wood waste, applying termiticides such chlorpyriphos, and utilising well-decomposed FYM, the termite attack can be minimised.

(iv). Crickets: At night, the adult stage crickets and nymphs emerge, cut off all the low branches and seedlings before dragging the remaining material to their tunnels to feed the young insects. Crickets frequently damage seedlings of *Ficus, Casuarina, Eucalyptus, Sisham, Teak, Rubber and Mango* trees. The insect can be controlled by deep ploughing during nursery site preparation and applying 200 g phorate or 5% fenitrothinon dust per bed.

(v). Minor and Non-insect Pests: The minor pests are grasshoppers, sapsuckers (green leaf hopper, white flies, thrips), and defoliators (beetles, weevils, and caterpillers). They can be regulated by spraying a formulation of any systemic insecticide, such as dimethoate 30 EC, or applying a 100 g dose of phorate 10% per bed. Among the significant non-insect pests include nematodes, rats, squirrels, hares, deer, mites, and birds. The most effective ways to mitigate damage from them are to manually scare them, use appropriate fence, and use rodenticides such zinc phosphide for killing. In addition to disease and pest damage, natural occurrences such as frost, freezing, drought, fire, and lack of nutrients can also result in reduced growth or seedling death.

12.5 General Control Measures

The several techniques used to manage different insect pests include:

(i) Mechanical Methods: This involves capturing insects and killing them using various methods of insect capture.

(ii) Silvicultural Method: Better cleaning, thinning, drainage, and hygiene are all included. It is best to remove any seedlings that are at risk of disease, wind, fire damage, etc. It is recommended to cultivate a variety of species to support parasites. Proper weeding and cleaning of the lower branches will encourage rapid growth in the seedlings developing in the nursery.

(iii) Biological Methods: Predators and pest parasites are become more prevalent while using the biological approach of management. It is also advised for insectivorous birders. Because of knowledge gaps and other limitations, this strategy is challenging to implement.

(iv) Chemical Control: Insect control involves the use of several chemicals, such as pesticides and insecticides. Their classification is as follows:

- Contact poison: Lime-sulphur, MIC, Aldrex, Dieldrine, Thimet, Paramor, Termax, Rogor, Dimecron, Aldrin.
- Stomach poison: Calcium arsenate, Sodium fluride etc.
- Fumigants: Creosote, nepthalene, bordeux mixture etc.
- Systemic insecticides.

Summary

- Climate records from the past and present should be assessed after closely observing the site's characteristics of the nursery. Plants cultivated in nurseries require special attention and precautions in order to ensure growth and development of the seedlings. It is necessary to take prompt and efficient precautions against unfavorable weather conditions, diseases, insects and pests. The operations i.e., shading; thinning; watering; weeding; hardening of seedlings; staking; de-shooting;

disbudding; pinching and pruning must be carried out in the nursery to ensure the development of high-quality seedlings.

- The symptoms of seedling stress, including as rust, powdery mildew, damping off, wilt, and root rot, are brought on by pathogen infection and cause the growth of seedlings to be slowed. These infections can spread by seed, the soil, or the air. The establishment of nurseries on freshly cleared land rarely attracts parasitic organisms. Seedlings with slow growth are usually the result of overwatering, planting them in shaded regions, or losing soil richness. Pre-treating seeds with fungicide, such as Captan, can suppress the disease and serve as a preventive strategy by sterilizing the nursery mixture. Fungicide can be applied in accordance with the identification of the unintentional pathogen by the expression of symptoms, should the disease emerge.
- These insect pests are categorized into three groups: major nursery pests (white grubs, cutworms, termites, and crickets), minor nursery pests (defoliators, sapsuckers, grasshoppers) and non-insect pests (nematodes and vertebrate pests). In general, improved nursery hygiene, the use of appropriate cultural techniques, and the proper application of chemical and biological pesticides only when necessary can reduce the impact caused by insects.
- There are several techniques such as Mechanical Methods, Silvicultural Method, Biological Methods and Chemical Control will be used to manage different insect pests.

Check your progress

1. Explain the various protection measures applied in nursery.
2. Explain different nursery disease and their management.
3. Discuss about the nursery insect-pests and their management.
4. Explain different general control measures applied in nursery.

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Ratha Krishnan, P., Rajwant K. Kalia, Tewari, J.C. and Roy, M.M. 2014. Plant Nursery Management: Principles and Practices. Central Arid Zone Research Institute, Jodhpur, 40p.

Unit 13: Nursery skill development: Field activities

Unit Structure

13.0 Learning Objectives

After completion of this unit, you will be able to:

- understand how to prepare nursery beds
- discuss the procedure of seed sowing
- understand plant growth regulators solution
- discuss the use of mist chambers
- understand the concept of hardening of plants;

13.1 Introduction

Plants are nourished at nurseries under favourable conditions; nursery produces billions of plants every year. Raising a nursery from seeds offers a simple and practical way to nourish tender and young seedlings in a well-managed, small and compact area, resulting in improved seed germination of expensive seeds. Establishing a nursery is a long-term effort that requires preparation and knowledge. Preparation of nursery beds is very important factor and sowing is a process of planting seeds into the ground. There are different methods of sowing and during sowing the seeds must be healthy and free from infection. Plant growth regulators are those compounds that are organic in nature but are different from other nutrients. They are used in small amounts and can promote, inhibit or alter the physiological processes in plants. Mist chamber is a unique structure used in nursery to provide minimum amount of water to the plants for their growth and development.

13.2 Preparation of nursery beds

The preparation of nursery beds is very important factor and there are 3 main nursery beds i.e., flat nursery bed, raised nursery bed and sunken nursery bed. Learners should recall section 1.4 of unit 1 for quick revision. Below is some exercise that helps you to prepare different types of nursery beds on the field.

13.2.1 Exercise

Objective: Preparation of nursery beds and sowing of seeds.

Materials required: Digging and hoeing implements, seed, measuring tape, rope and wooden pegs, organic manures (FYM), mulching material.

Procedure: A nursery beds are of three types

Flat nursery bed

Raised nursery bed

Sunken nursery bed

Flat nursery bed: It is prepared in the spring and summer when there is no chance of rain, in locations with light sandy to sandy loam soil, and without any issues with water stagnation. The nursery space is adequately prepared, with the land and well-rotten FYM ground to a particle size of 10 kg per square meter and well mixed into the soil. The field is separated using a layout rope and measuring tape into small plots made up of beds that are all the same size based on what is needed. Each bed has ridges prepared around it to support the cultural customs. A control irrigation canal is set up between every two rows of beds, via which every bed is connected.

Raised nursery bed: It is especially helpful for growing seedlings during the rainy season, when water stagnation can become an issue and lead to disease damping off. A raised bed that is 10 to 15 cm above the floor is ready. After removing all of the weeds, stones, pebbles, stumps and other debris from the bed, FYM is mixed into the soil at a rate of 10 kg per square meter. A 45 to 60 cm gap is left between rows to facilitate the easy execution of cultural acts. In the bed, the seeds are sown in rows.

Sunken nursery bed: During the winter, this kind of bed is prepared and beneficial. The preparation of this kind of nursery begins 10 to 15 cm below the soil's surface. The cold breeze of the air does not reach the seedlings in the sunken bed as it blows across the soil's surface. Moreover, it is simple to cover a sunken bed with polyethylene sheets, which is necessary to shield the seedlings from chilly air.

Precautions:

1. Nursery bed should be made at proper depth.
2. Prevent nursery beds from overwatering and stress condition.

13.3 Sowing of Seeds

Sowing is a process of planting seeds into the soil or putting seeds into the ground. There are various methods of seed sowing like broadcasting, line, strip, spot and dibbling method. During all these nursery operations proper precaution should be followed such as

- maintaining proper distance
- depth
- clean and healthy soil

In section 1.6 of unit 1, this topic is already explained and you can recall it from there. Here is some exercise based on your knowledge.

13.3.1 Exercise

Objective: Preparation and method of seed sowing in nursery bed

Materials required: Digging and hoeing implements, seed, measuring tape, rope and wooden pegs, organic manures (FYM), mulching material.

Procedure: Clear the soil of any stones, pebbles, crop leftovers, etc. to get a fine tilth. Level the ground/bed and break up the clods. Combine FYM@ 3 to 4 kg, 250 g superphosphate, and 250 g ammonium sulphate per square meter. The seeds are spaced 8 to 10 cm apart and 2 to 4 cm deep. The size of the seeds determines the furrow's depth (Deeper the furrow, the bigger the seeds). Following seeding, a 3:1 mixture of FYM and coarse sand should be applied to the seeds. After mulching the seed beds as needed, level the bed and add water. It is best to avoid overwatering because too much moisture promotes the growth of root rot.

In situ sowing: When seeds are sown directly in the field, grafting and budding are done there as well. This technique is known as "in situ sowing." It is especially crucial for some fruits with long tap roots, such as jackfruit, walnuts, and pecan nuts. It is possible to prevent harm to tap roots during plant transplantation or uprooting from nurseries by using in situ sowing. Similarly, in situ orchard establishment is advised for high density planting of Amrapali mango.

Precautions:

1. The seed source needs to be reliable and authentic.
2. Depending on the size of the seed, the depth of planting should be carefully determined.

13.4 Plant Growth Regulators (PGR)

Plant growth regulators are natural or synthetic compounds that affect metabolic and developmental processes in higher plants, even at low concentrations (**Fig. 1**). These are organic compounds other than nutrients that promote, inhibit or otherwise modify any physiological process in plant.

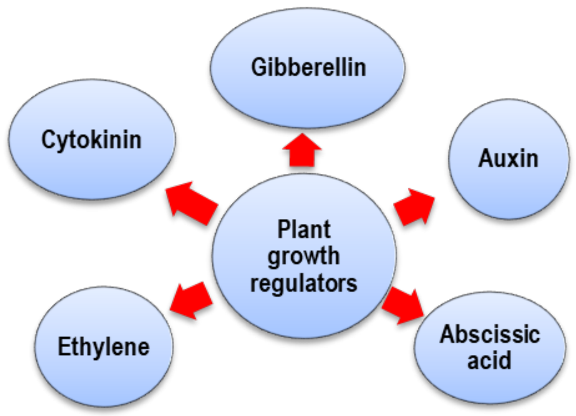

Fig. 1: Plant growth regulators

The naturally occurring growth substances are commonly known as plant hormones, while the synthetic ones are called growth regulators. Auxin, Gibberellins, Cytokinins, Ethylene and Abscissic acid are the main plant growth regulators. Plant growth regulators are useful for propagation of plants, seed germination, control of plant size, regulate flowering, control sex expression and fruit drop, prevent sprouting and early ripening and development of fruit colour.

The quantitative increase in plant body such as increase in the length of stem and root, number of leaves is referred to as plant growth, whereas, the qualitative changes such as germination of seed, formation of leaves, flowers and fruits, falling of leaves and fruits is referred as development of plant. The growth and development of the plant is controlled by two main internal factors *i.e.*, nutrition and hormone. The raw material required for growth is supplied by nutritional factors which include the minerals, protein and carbohydrates. Utilization of nutritional factors for proper development of the plant is regulated by certain "chemical messengers" called as plant growth substances or plant growth regulators. These plant growth regulators are used in minute amounts, increases or decreases or modify the physiological process in the plants.

13.4.1 Effect of different plant growth regulators

Auxin helps in Apical dominance, cell expansion, shoot and root growth, parthenocarpy, tropism while gibberellins promote cell growth, flower induction, fruit set and development, seed development, germination and parthenocarpy. Cytokinins helps in cell division, anti-ageing or anti-senescence effect, anti-stress effect and gall or nodule formation and ethylene controls senescence, fruit ripening, abscission and environmental stress. The last growth regulator helps in seed development, growth control, water stress and abscission.

13.4.2 Seed germination

The process in which seed begins to grow and eventually develops into a seedling. Water, gases, nutrients, temperature and light are the basic requirements for seed germination (**Fig. 2**). Seed germination is of two types: **Epigeal**

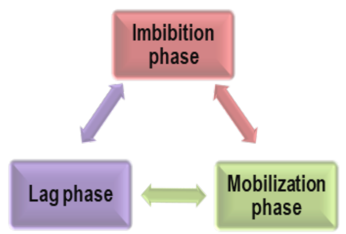

Fig. 2: Phases of seed germination

and **Hypogeal** and has 3 phases; **imbibition**, **lag phase** and **mobilization of reserve food**.

13.4.3 Vegetative propagation

Propagation of plants involves the formation and development of new individuals, which are used in establishment of new plantings. Two methods are employed in propagation *i.e.*, sexual and asexual. Vegetative propagation is also called as asexual propagation, it is the multiplication of a plant through some vegetative parts and used cuttings, layering, and grafting.

Let's do some exercise for the preparation of different plant growth regulator solutions and their methods of application.

13.4.4 Exercise

Objective: Preparation and application of plant growth regulator solutions for seed germination and vegetative propagation.

Materials Required: Plant growth regulator(s), measuring cylinder, volumetric flask, beaker(s), electronic balance, distilled water.

Procedure: Making the growth regulator solution: Parts per million, or ppm, is the unit of measurement used to determine the strength of growth regulators. One litter of water has 1.0 mg of the chemical dissolved in one ppm. The necessary amount of growth regulator should be weighed, then transferred to a beaker and dissolved with a little amount of solvent. Auxins can dissolve in 0.1% NaOH or alcohol. While cytokinins can dissolve in 1-2 ml of N/10 HCl, gibberellins are soluble in pure alcohol. In NaOH, abscisic acid dissolves quite easily. Until the chemical or growth regulator is completely dissolved, shake the beaker. Now pour it into a volumetric flask and use distilled water to reach the desired final volume of one liter. One should prepare a new solution for each use. The formula below is used to convert hormonal strength.

1. Percent solution = ppm /10,000
2. ppm solution = % x 10000

Preparation of hormonal powder: The necessary amount of hormone is carefully weighed using a delicate balance in order to prepare hormonal powder. It is dissolved in a beaker containing ½ liter of ethanol, methanol, or acetone. Using a glass rod, thoroughly mix one kg of talc that has been placed in a mortar. The combination is mixed and then left out in the open for a few hours. The alcohol will soon evaporate, and the talc that has dried will then be crushed into a fine powder. This fine powder can be used as needed and should be stored in airtight containers to prevent moistening.

Preparation of hormonal paste: The necessary amount of hormone is precisely weighed and fully dissolved in a few drops of alcohol to prepare hormonal pastes. Weighing out the necessary amount of lanolin (wool fat, a substance that resembles grease and has a greenish-yellow tint), we gently heat it in a beaker over low heat. The dissolved hormone is put into the lanolin once it has softened a little. Using a glass rod, the mixture is thoroughly dissolved while being stirred continuously. The mixture is given time to cool. The paste can now be used. The paste can be stored for a few months in a cold, dry area until needed, but it is best to use fresh paste.

Method of application of growth regulators: Growth regulators work best when applied in a certain way and at a specific concentration. The most popular and efficient rooting hormone is auxin. It has been discovered that IBA and NAA are the most successful synthetic auxins at promoting roots. The following are the many techniques used to treat cuts and layers:

1. **Prolonged soaking method**: Using this technique, cuttings' basal ends are immersed in the hormone's diluted solution for a full day in a cool, dry environment. 16 hormone or growth regulator concentrations typically range from 20 ppm to 200 ppm, depending on the style of cutting and the species of plant. Cuttings are planted in growth media after treatment. In growth media, the concentration is often little. For species that are simple to root, the concentration is typically low, and vice versa. This technique, which also uses vitamins, carbohydrates, and nitrogenous chemicals in addition to growth regulators to aid in rooting, is highly helpful for species that are challenging to root.

2. **Quick dip method**: Depending on the species to be propagated, the basal end of cuttings in this procedure are dipped in a concentrated hormone solution for a brief period of time, typically 5 to 2 minutes. The field or rooting medium is planted with treated cuttings. Depending on the species and type of cutting, the hormone concentration for the rapid dip approach can range from 500 to 10,000 ppm; however, 3000 to 5000 ppm is typically employed.
3. **Powders dip method**: Additionally, basal ends of cuttings are dipped in the hormonal powder (talc) in this procedure, which transports the hormones for a while. Cuttings should be treated, any excess powder that sticks to them should be shaken off, and then they should be placed right into the rooting medium. Cutting ends should be wet before treatment for optimal rooting, and any excess powder that sticks to the cuttings should be brushed off to prevent negative effects on the rooting process. Powder forms of Seradix, Rootex, and numerous more formulas are sold on the market.
4. **Lanolin paste method**: The growth regulator paste created with lanolin is applied to the girdled part of a layer or faeces, as explained under the creation of hormonal paste, to induce roots in them.
5. **Spray method**: Sometimes mother plants are sprayed with growth regulators before to cuttings being taken from them. About 30 to 40 days prior to taking cuttings from stock plants, 2,4,5-T is sprayed on them at concentrations ranging from 25 to 100 ppm. Cuttings from these plants root more readily than cuttings from untreated plants.

Precaution:

1. Start by looking at the hormone powder's expiration date.
2. The weight should be taken precisely, ideally using an electronic balance.
3. To prevent precipitation, use the appropriate solvent.
4. Store hormones in a dry, cool place as they will degrade in high temperatures.
5. As hormones are photosensitive, they need to be kept in dark or amber-colored containers.
6. Apply lanolin paste to layers and hormonal solutions to cuttings.

7. Fresh solutions ought to be made. If required use refrigerators to store for some time.
8. To prevent the solution from being removed from the cutting's basal end, the treated cuttings should be planted with the assistance of a stick to create a hole.

13.5 Mist chambers

This is a unique structure in a nursery where leafy soft-wood cuttings are successfully propagated. Many shrubs and plants that are challenging to root effectively root in mist. The idea is to use as little water as possible to spray the cuttings in order to keep the appropriate amount of humidity. The simplest way to accomplish this is to spray the cuttings intermittently-that is, in short, frequent bursts-as opposed to continuously. When combined with a time switch and a high-pressure pump, this kind of sporadic spraying is simple to accomplish. Cuttings can be raised in a mist chamber year-round, with the sole exception of December to January in northern India and April to May in eastern India. It is feasible to raise cuttings all year round in southern India. This topic was well explained in section 1.8 of unit 2, learners can refer it for additional information. Exercise on use of mist chamber for propagation and hardening of plants is given below:

13.5.1 Exercise

Objective: Use of mist chamber for propagation and hardening of plants.

Materials required: Mist chamber, cuttings, secateurs, hormone solution and sand.

Procedure: Mist propagation units are used to propagate cuttings that are hard to root. Misting is primarily used to provide a constant layer of water on the leaves by minimizing transpiration and maintaining the cuttings turgid until they begin to root. The misting is managed by a time clock that operates a magnetic solenoid value. It is programmed to turn on the mist for three to five seconds to moisten the leaves, then to turn off for a while. The mist is then turned back on after the leaves have dried. There are typically **five** ways that mist is controlled:

Timer: A mist unit uses two different kinds of timers: one that runs in the morning and shuts off at night, and another that runs during the day to create a sporadic mist, often lasting 60 seconds on and 90 seconds off.

Electronic leaf: When cuttings and a plastic with two terminals are submerged in a mist, the terminals' alternating drying and wetting cuts off the current, which in turn regulates the solenoid value.

Thermostat: The temperature of mist is controlled by using thermostat.

Screen balance: It is comprised of a stainless-steel screen fastened to a mercury switch lever. The mercury switch is tripped when there is an excessive amount of weight, and the mist is controlled on the screen.

Photoelectric cell: It is based on the relationship between light intensity and transpiration rate.

Hardening of plants in mist chamber: For improved field survival, the rooted cuttings must be hardened after rooting in the mist. Misting shouldn't stop abruptly after cuttings have rooted because this could cause young plants to dry out from burning. The weaving off method, which keeps misting while progressively reducing the amount of sprays, ought to be used. It can be achieved by shortening the "On" period and lengthening the "Off" period. Moving the rooted cuttings to a greenhouse, fog chamber, or frames kept at a warmer temperature and lower relative humidity is an additional method. Hardening should be done in phased manner so that rooted cuttings are planted at permanent locations.

Precautions:

1. A steady supply of water ought to be available.
2. Hard and alkaline water should be avoided since it clogs the nozzles; water with a pH of 5.5 to 6.5 is ideal.
3. Aeration of rooting media should be enough.
4. Prevent the growth of blue green algae in the mist chamber.

Summary

In this unit, we have discussed about preparation of different types of nursery beds and seed sowing methods. This unit also covers the concept and importance of plant growth regulators for the growth and development of plants raised in nursery. Seed germination and vegetative propagation was also discussed in this unit. Seed germination is a process in which seed starts growing into seedling while vegetative propagation means multiplication of a plant through some vegetative parts. Different exercises based on these topics were also discussed. This unit describes about mist chambers and their use for propagation and hardening of plants. Overall, this unit summarizes all the practical exercises that shall be done in the field for the proper management of the nursery.

Terminal Questions

1. How raised nursery beds are prepared?
2. Briefly explain the steps used for the preparation of flat and sunken beds.
3. How seed sowing is done?
4. What do you understand by the term plant growth regulators.
5. How plant growth regulators affect the development of plants?
6. Explain seed germination and vegetative propagation.
7. How hormonal powder and paste are prepared?
8. Briefly explain the method of application of growth regulators.
9. Explain mist chambers and its use in nursery.
10. How mist chambers are used for hardening of plants?

Answers to Terminal Questions

1. see section **13.2.1**
2. see section **13.2.1**
3. see section **13.3.1**
4. see section **13.4**
5. see section **13.4.1**
6. see section **13.4.2** and **13.4.3**
7. see section **13.4.4**
8. see section **13.4.4**
9. see section **13.5**
10. see section **13.5.1**

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Unit 14: Nursery Skill Development: Field Activities

Unit Structure

14.0. Learning Objectives

After studying this unit, you should be able:

- To have basic understanding of pattern of showing
- To understand spacing requirement in a nursery
- To understand about the quantity of seed requirements in a nursery.

14.1 Introduction

Forest nursery is an area where plants are raised for eventual planting out; has ordinarily both seedlings and transplants (Anon, 1966). Seedlings are young plants obtained from seed sowing. These young plants can be about one meter in height. Transplants are seedlings which have transferred from one bed to another to make the seedlings suitable for planting. Seedlings, transplants and other planting material e.g. rooted cuttings etc. together are generally called planting stock. The selection of site from nursery is influenced by several factors i.e. Central location, Accessibility, topography, soil condition, water, labour and management, vegetation and Aspect and altitude etc.

14.2. Patterns of sowing

The seeds are sown in beds, polythene bags or in any other containers. The assed can be sown by (i) Dibbling, (ii) Drilling or (iii) Broadcast methods etc.

Dibbling- Dibbling is the process of placing seeds in holes at definite depth and fixed spacing made in seedbed and covering them. This method is also known as line sowing method. The equipment used is called Dibbler contains a conical instrument used to make proper holes in the field. Small hand dibblers are made with several conical projections made in a frame.

Drilling– Drilling consists of dropping the seeds in furrow lines in a continuous flow and covering them with soil. This method is very helpful in achieving proper depth, proper spacing and proper amount of seed to be sown in the field. In agriculture, most seed is now sown using a seed drill, which offers greater precision; seed is sown evenly and at the desired rate.

Broadcasting: It is the process of random scattering of seed on the surface of seedbeds. In broadcasting system higher seed rate is obtained.

Sowing seed behind the plough: It is a frequent practice in communities, where, a man puts seeds into the furrow. Hal is an instrument that allows you to sow behind the plough. It comprises of a bamboo tube with a funnel-shaped mouth. One man drops the seeds via the funnel, while the other man manages the plough and bullocks.

Hill Dropping: This method involves dropping seeds at a set spacing rather than in a continuous stream. Unlike drilling, this approach maintains a steady space between plants in a row.

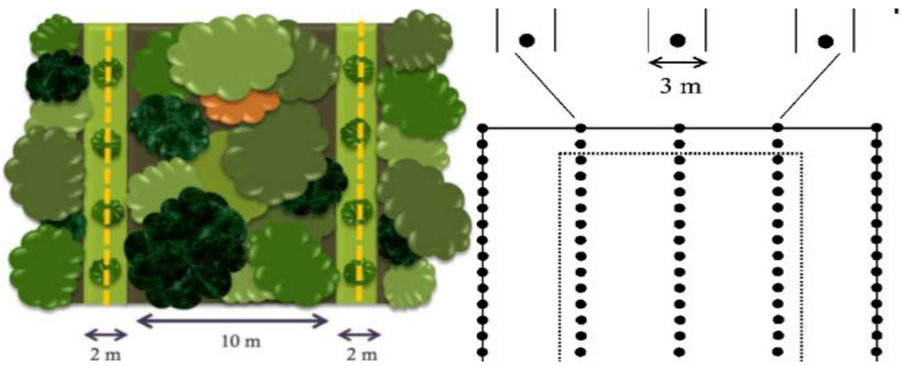
Check row planting: This planting strategy ensures a consistent space between rows and plants. This approach involves planting seeds exactly along straight parallel furrows. The rows are always in two perpendicular directions. Check row planter is used to check row planting.

Transplanting– Transplanting consists of preparing seedlings and then planting these seedlings in the prepared field. It is commonly known planting method. Transplanter is used for placing plants in the soil.

- ✓ Planting is the activity of arranging planting material in the form of seeds or seedlings on planting media, both soil and non-soil media, in a pattern as the first step in plant cultivation.

- ✓ The percentage of growth can be used to calculate the success of planting activities. The percentage of living plants compared to the total number of plants planted on cultivated land is known as the growth percentage.
- ✓ A cropping pattern is an effort to plant on a plot of land by arranging the layout and order of plants for a specific period of time, including tillage and periods of not being planted.

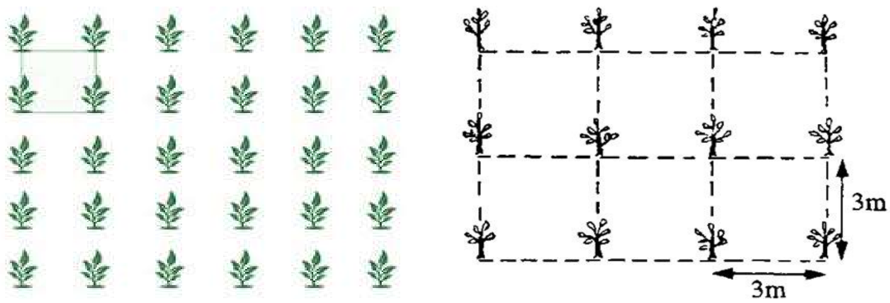
Line planting: In line planting, plants are planted at some spacing in lines. Thus, the planted plants form rectangles.



Number of plants/ha= $\frac{\textbf{100 X 100m}}{\textbf{Distance between plants in lines X distance between the lines}}$

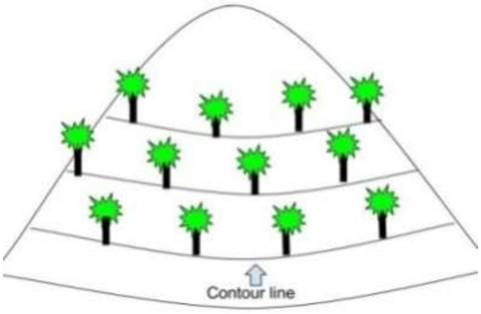
Square planting: This system is considered to be the simplest of all the system and is adopted widely. In this system, the plot is divided into squares and tree seedlings are planted at the four corners of the square, in straight rows running at right angles.

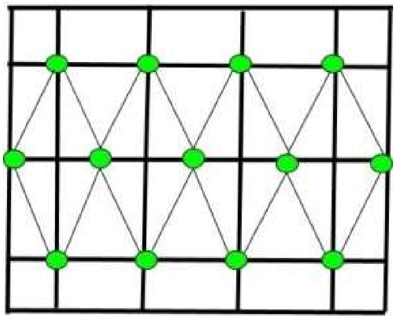
Number of plants/ ha = $\frac{\textbf{100 X 100m}}{(\textbf{Planting distance})\textbf{2}}$



Triangular planting: In this planting pattern plants are planted at equilateral triangles i.e. with plants occupying in three corners of each adjacent equilateral triangles.

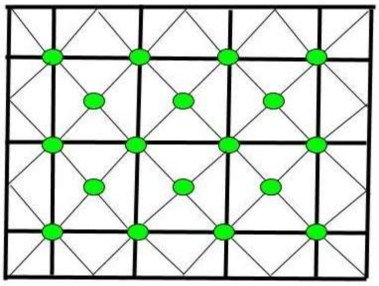
$$\textbf{Number of plants/ha} = \frac{(100 \text{ X } 100 \text{ m}) \text{ X } 1.155}{(\text{Planting distance})2}$$

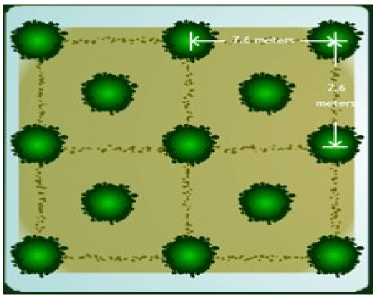




Quincunx planting: This system of planting is similar to square system, except that a fifth tree seedling is planted at the centre of each square. As a result the tree number in a unit area becomes almost double the number in the square system. The additional tree in the centre is known as “filler”. The fillers are usually quick growing and early maturing.

$$\textbf{Number of plants/ ha.} = \frac{2 \text{ X } (100 \text{ X } 100\text{m})}{\text{Distance between plants in row or column}}$$





Exercise-1

Objective: To determine number of plants in 10 hectares of plantation under different planting pattern with spacing of:

(a) 2 x 8 meter (b) 2.5x2.5 m

(c) In triangular pattern 3.5 m apart (d) 3.5 x 3.5 with a plant in center of each square

Requirement: Measuring tape, field book, notepad etc.

Principle: Number of plants required per hectare under different planting patterns can be calculated by the formulae given below (Kumar, 2011), but in actual practice 10 to 20% of plants have to be arranged extra for providing mortality of plants in extraction from nursery, transport to the planting site or at the time of planting.

Methods:

(a) In Line planting with spacing of 2x8 m

Number of plants in 10 ha. $= \frac{\mathbf{10\ X\ (100\ X\ 100m)}}{\mathbf{Distance\ of\ plants\ in\ lines\ X\ distance\ between\ the\ lines}}$

Number of plants = $\frac{10\ \ X100\ X\ 100}{2\ X\ 8m}$ = 6,250 plants

(b) In Square planting with spacing of 2.5x2.5 m

Number of plants in 10 ha = $\frac{10\ \ X(100\ X\ 100m)}{2.5\ X2.5m}$ = 16,000 plants

(c) In triangular pattern with 3.5 m spacing

Number of plants in 10 ha = $\frac{10\ \ X(100\ X\ 100m)\ X\ 1.155}{3.5\ X\ 3.5m}$ = 9,428 plants

(d) Quincunx planting with 3. 5 x 3.5m spacing with a plant in center square

Number of plants in 10 ha = $\frac{10\ \ X\ 2\ X(\ 100\ X\ 100m)}{3.5\ X\ 3.5m}$ = 16,326 plants

Results: Estimated number of plants in 10 ha area for line planting is **6,250 plants**, square planting **16,000 plants**, for triangular planting **9,428 plants** and quincunx planting **16,326 plants**.

Exercise-2

Objective: To determine number of plants in 16 hectares of plantation under different planting pattern with spacing of:

(a) 4x5 meter

(b) 5x5 m

(c) In triangular pattern 4 m apart

(d) 2 x 2 with a plant in center of each square

Requirement: Measuring tape, field book, notepad etc.

Principle: Number of plants required per hectare under different planting patterns can be calculated by the formulae given below (Kumar, 2011), but in actual practice 10 to 20% of plants have to be arranged extra for providing mortality of plants in extraction from nursery, transport to the planting site or at the time of planting.

Line planting:

Number of plants/ha = $\frac{100 \text{ X } 100}{\text{Distance between plants in lines X distance between the lines}}$

Square planting:

Number of plants/ ha = $\frac{100 \text{ X } 100\text{m}}{(\text{Planting distance})2}$

Triangular planting:

Number of plants/ha = $\frac{(100 \text{ X } 100 \text{ m}) \text{ X } 1.155}{(\text{Planting distance})2}$

Quincunx planting:

Number of plants/ ha. = $\frac{2 \text{ X } (100 \text{ X } 100\text{m})}{\text{Distance between plants in row or column}}$

Methods:

(a) In Line planting with spacing of 4x5 m

Number of plants = $\frac{16 \text{ X} 100 \text{ X } 100}{4 \text{ X } 5\text{m}}$ = 8,000 plants

(b) In Square planting with spacing of 4x4 m

Number of plants in 16 ha = $\frac{16 \text{ X}(100 \text{ X } 100\text{m})}{4 \text{ X} 4\text{m}}$ = 10,000 plants

(c) In triangular pattern with 4.0 m spacing

Number of plants in 16 ha = $\frac{16 \text{ X}(100 \text{ X } 100\text{m}) \text{ X } 1.155}{4 \text{ X } 4\text{m}}$ = 11,550 plants

(d) Quincunx planting with 2 x 2m spacing with a plant in center of each square

Number of plants in 16 ha = $\frac{16 \text{ X } 2 \text{ X}(100 \text{ X } 100\text{m})}{2 \text{ X} 2\text{m}}$ = 80,000 plants

Results: Estimated number of plants in 10 ha area for line planting is **8,000 plants**, square planting **10,000 plants**, for triangular planting **11,550 plants** and quincunx planting **80,000 plants**.

14.3 Spacing

Actual spacing varies with species, site, and the purpose of the forest plantation. In fuelwood plantations, for example, one might prefer closer spacing's than employed in other kinds of plantations. Seldom can a spacing of less than 3 x 3 meters be applied, however. Aside from aesthetics, proper plant spacing is essential for long-term plant health. When plants are close together, they compete for water, nutrients, and light. Crowded plants frequently fail to blossom due to insufficient nourishment or a lack of light reaching the shaded branches.

Proper plant spacing also promotes adequate air circulation around plants, aiding in the fight against plant diseases. Many disease pathogens need a damp or humid environment to thrive. In densely packed plantings, restricted ventilation prevents moisture from evaporating from leaf surfaces, increasing the risk of foliar diseases. Proper plant spacing improves air circulation and helps avoid fungal diseases in the garden.

Spacing of a given number of plants planted in various patterns can be calculated by the following formula following Kumar, 2011:

<u>Square planting:</u>

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare}}} = \text{meter square}$$

<u>Rectangular planting:</u>

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare X spacing of plants in rows}}} = \text{meter square}$$

Triangular planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100 \text{ X} 1.155}{\text{No of plants per hectare}}} = \text{meter square}$$

Quincunx planting:

$$\text{Spacing} = \sqrt{\frac{2 \text{ X } 100 \text{ X } 100}{\text{No of plants per hectare}}} = \text{meter square}$$

Exercise - 3

Objective: Determined the spacing of 4000 plants/ha raised on different planting pattern:

1) Square planting pattern.
2) Spacing of plants in row is 2 meter
3) Spacing of plants in row is in triangular pattern
4) Spacing of plants in Quincunx pattern

Requirement: Measuring tape, field book, notepad etc.

Principle and Method: Spacing of a given number of plants planted in various patterns can be calculated by the following formula following Kumar, 2011:

Square planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare}}} = \text{meter square}$$

Rectangular planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare X spacing of plants in rows}}} = \text{meter square}$$

Triangular planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100 \text{ X} 1.155}{\text{No of plants per hectare}}} = \text{meter square}$$

Quincunx planting:

$$\text{Spacing} = \sqrt{\frac{2 \text{ X } 100 \text{ X } 100}{\text{No of plants per hectare}}} = \text{meter square}$$

Results:

Square planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare}}} = \sqrt{\frac{100 \text{ X } 100}{4000}} = \sqrt{2.5} = 1.58 \text{ m}^2$$

Rectangular planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100}{\text{No of plants per hectare X spacing of plants in rows}}} = \sqrt{\frac{100 \text{ X } 100}{4000 \text{ X } 2}}$$

$$= 1.12 \text{ m}^2$$

Triangular planting:

$$\text{Spacing} = \sqrt{\frac{100 \text{ X } 100 \text{ X} 1.155}{\text{No of plants per hectare}}} = \sqrt{\frac{100 \text{ X } 100 \text{ X } 1.155}{4000}} = \sqrt{2.89} = 1.70 \text{ m}^2$$

Quincunx planting:

$$\text{Spacing} = \sqrt{\frac{2 \text{ X } 100 \text{ X } 100}{\text{No of plants per hectare}}} = \sqrt{\frac{2 \text{ X } 100 \text{ X } 100}{4000}} = \sqrt{5} = 2.24 \text{ m}^2$$

Conclusion: Spacing of plants in square planting is **1.58 m^2**, Rectangular planting is **1.12 m^2**, Triangular planting is **1.70 m^2** and Quincunx planting is **2.24 m^2**.

14.4 Quantity of seed requirement

Seeds are most important component for raising the nursery and development of field plantation. The approximate amount of seeds will be helpful for raising the plantations in a required area. A rough estimate of the quantity of seeds that will be required for sowing in a specified bed as given above. Weight of the required seeds can be calculated with the following formula:

$$W = \frac{A \text{ X } D}{P \text{ X } N} \text{ X } 100$$

Where W=weight of seeds required A=Area of nursery bed (m^2)

P=Plant percent of species D= number of plants required per m^2

N=Number of seeds per gram

Exercise-4

Objective: Calculate the quantity of Teak seeds required for a nursery bed of 5 x 3.5 m, which are to be sown at a distance of 25 x 25 cm. The viability of the seeds is 90 per cent and number of seeds per gram is 30.

Requirement: Seeds, Measuring tape, field book, notepad etc.

Principle: Seeds are most important component for raising the nursery and development of field plantation. The approximate amount of seeds will be helpful for raising the plantations in a required area. A rough estimate of the quantity of seeds that will be required for sowing in a specified bed as given above.

Method: Weight of the required seeds can be calculated with the following formula:

$$W = \frac{A \times D}{P \times N} \times 100$$

Calculation:

A**=** Area of nursery bed = 5 x 3.5 or 17.5 m^2

D= Number of plant required / m^2 = the distance is 25 x 25 cm or 625 cm^2, thus in 1m^2 a total of 16 plants will be raised.

P= Plant percent of species= 90

N= Number of seeds per gram = 30

Putting these values in formula we get: $W = \frac{A \times D}{P \times N} = \frac{17.5 \times 16}{90 \times 30} \times 100 =$ **10.07g**

Result: Calculated quantity of Teak seeds required for a nursery bed of 5 X 3.5m is **10.07g.** For broad cast sowing in nursery, the quantity of seeds calculated is multiplied by six and for drill sowing the quantity is doubled. Generally broadcast sowing is done for minute seed for example Eucalyptus, Poplar etc.

Exercise-5

Objective: Plantation of *Shorea robusta* is to be done in an area of 20 hectare with a spacing of 5 X 5m. The plant per cent is 80 and number of seeds per gram is 10. About 300 extra seeds are required to cover germination as well as plant failure. Calculate the quantity of seeds required in kg.

Requirement: Measuring tape, field book, notepad etc.

Principle: Seeds are most important component for raising the nursery and development of field plantation. The approximate amount of seeds will be helpful for raising the plantations in a required area.

Method: The amount of seed for sowing a particular size of plot can be determined as:

$$\textbf{Quantity of seed (kg)} = 125 \text{ X } \frac{nX\ A}{P\ X\ W} + C$$

Where W= number of seeds per kg A=Area (ha) of plantation

P=Plant percent of species n= number of seedlings to be planted per ha

C= extra quantity to cover germination failure of some seeds.

Calculation:

The spacing of plant is 5 x 5 m or 25m^2 in 1 ha (100 X 100m)

Total plants may be raised=		400 plants
A**=**	Area of plantation =	20 hectare
n=	Number of seedlings to be planted / ha	400
P=	Plant percent of species=	80
W=	Number of seeds per kg =	10x1000=10000 seeds
C=	Extra quantity to cover germination failure of some seeds=	300

Putting these values in formula we get: W=$125 \text{ X } \frac{\text{n X A}}{\text{P X W}}$=

$$125 \text{ X } \frac{400 \text{ X } 20}{80 \text{ X } 10000} + 300 = \mathbf{301.25\ kg}$$

Result: 200.98 kg seeds of *Shorea robusta* required for the plantation of 20 hectare area.

Summary

Forest nursery is an area where plants are raised for eventual planting out; has ordinarily both seedlings and transplants. Seedlings are young plants obtained from seed sowing. Transplanting consists of preparing seedlings and then planting these seedlings in the prepared field. It is commonly known planting method. Planting may be done following Line, Triangular, Square and Quincunx planting pattern.

Terminal Question

1. Discuss Pattern of showing?
2. Determine number of plants in 2 hectares of plantation under different planting pattern with spacing of :

   (a) 2 x 4 meter (b) 2x2 m

   (c) In triangular pattern 2.5 m apart (d) 1.5 x 1.5 with a plant in center of each square

References

1. Kumar V., 2011. Nursery and Plantation Practices in Forestry IInd edision. Scientific publishers (India), Jodhpur, Rajesthan.