**YASHWANTRAO CHAVAN MAHARASHTRA OPEN UNIVERSITY**

# Resource Book on
# Horticulture Nursery Management

राकृनप
NAIP

**Developed Under**

**National Agricultural Innovation Project,**

**Indian Council of Agricultural Research, New Delhi - 110012.**

# Yashwantrao Chavan Maharashtra Open University

## Resource Book on

# Horticulture Nursery Management

***Index***

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# Unit 1: Introduction to Horticulture Nursery

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## 1.1 Introduction

Agriculture and Horticulture are vital sciences as they suffice the very basic need of food for the Human beings. Qualitative and quantitative food can essentially be produced from healthy plants which in turn are produced only when their seedlings/sapplings are vigorous and healthy. Nursery is consequently the basic need of horticulture. Plant propagation techniques and practices is the core of horticulture nurseries. The planting materials for horticultural plantations are raised from seeds and vegetative parts.

Role of Mother Plants is very primary and important. The fate of nursery depends on quality and truthfulness of mother plants. A good nursery entrepreneur does not depend on others for procurement of mother plants. Mother plants are required for both stock and scion. Mother plants should be selected on the basis of its genetic traits and other factors like availability and adaptation in the growing environment.

**At the end of this unit, you will be able to know and understand,**

- Importance of plant propagation nurseries.
- Role of nurseries in Horticultural development.
- Types of plant propagation nurseries.
- Various sections in the nursery and their importance.
- Financial and other resources for the nursery enterprise.

## 1.2 Contents

### 1.2.1 Scope and Importance of Plant Propagation in Horticulture

Most of the horticultural plants, particularly the fruit trees, are perennial in nature. Some of the fruit trees survive and produce fruits for about 100 years. Horticulture has a significant role in human nutrition. It plays a prime role in wealth generation and socio-

economic status of the farmers. Most of the horticultural crops are propagated vegetatively for which nursery units are necessary. There are plentiful programs being implemented to develop the nurseries and there by bringing about horticultural development.

**Importance of Plant Propagation for Landscaping**

Landscaping one's home is a very personal process. A garden should necessarily be unique and reflect the owner's personality. The value of a designed garden or landscape escalates with its age. Same is the case with the plants. If a small evergreen plant fetches a prize of Rs. 100 at the time of planting, it is bound to fetch Rs 500 after 5 years of its growth. A designed garden not only increases the appeal and privacy of the property but it also adds to the value of the property.

Nowadays, landscaping and garden architects have become a part of the modern life. To design and develop the modern corporate gardening, the professionals use periodicals and magazines which are specialized in this respect.

**Importance of Plant Propagation for Starting a Backyard Plant Nursery**

When people think of a plant nursery, the local garden center usually comes to mind. Fact is, most garden centers produce very few of the plants they sell. Instead, they procure the planting material from outside nurseries, which actually grow the plants. One finds specialty plant nurseries ranging in size from tiny backyard nurseries to giant regional wholesale nurseries, who supply retailers in the adjoining states of the country.

A backyard plant nursery often specializes in plants that are in demand and can be container-grown to save space. A relatively new development in container growing – called the "pot-in-pot" system, allows growers to produce larger trees and shrubs without the back-breaking hand digging and high water consumption required for field growing. For smaller plants, container growing saves time, water and transplanting. Growers who live in a small town or rural area can also make a good income focusing on wholesale plant sales to retail nurseries and landscapers around their region.

**A Backyard Plant Nursery**

Some nurseries just replant young plants obtained from wholesale specialized nurseries, rear these plants till they attain a certain size in larger pots or containers and then sell these plants. Once mother plants are obtained one can easily propagate more by cuttings or root division and reduce the plant propagation cost. This can really make a difference with ground covers and ornamental grasses, for example, because most customers need dozens of saplings, not just one or two.

**Specific Importance of Plant Nursery**

1. Seedlings and grafts are produced in nursery and the fruit orchards and ornamental gardens can be established with minimum care, cost and maintenance.
2. The nursery planting materials are available at the beginning of the planting season. This saves the time, money and efforts of the farmers to raise seedlings.
3. There is a wide scope for fruit orchards, ornamental, vegetable, and landscape gardens at public gardens, highways and co operative housing societies.

## 1.2.2 Role of Nurseries in Horticulture Development

1. **Production of Genetically Pure Nursery Stock**
   Genetically pure planting material is essential for healthy and vigorous plant growth. Both stock and scion should be genetically pure. The planting material should be satisfactory in quantity and quality and easily available for further multiplication.
2. **Export of Nursery Stock**
   Globalization has improved the chances of export of quality planting material to other countries. Special techniques and care is required for exporting the nursery material. Similarly, great care is necessary while importing nursery material from outside.
3. **Employment Generation**
   There is a huge demand of skilled professionals for grafting, budding, potting, repotting and other nursery operations. Nursery provides employment opportunities for technical, skilled, semi-skilled, and unskilled labor. Nursery can itself be a very remunerative enterprise in the changing national scenario.
4. **Role of Nurseries in Dry Land Horticulture**
   Like India, there are many countries in this world, which face droughts every other year. Growing drought tolerant fruit crops provide assured income to farmers. Horticultural plantations play an essential part in afforestation and thereby help to reduce the global warming.

## 1.2.3 Types of Plant Propagation Nurseries

A nursery is a place where plants are propagated and grown to usable size. The various types of nurseries can be classified based on various criteria. They include,

Sale: Retail nurseries which sell to the general public. Wholesale nurseries, which sell only to businesses such as other nurseries and to commercial gardeners, private nurseries which suffice the needs of institutions or private estates. Some retail and wholesale nurseries sell by mail.

Phase of the process: propagation, growing out, or retail sale;

Type of plant: Ground covers, shade plants, fruit trees, or rock garden plants.

The nursery business is highly seasonal. It is affected by temperature, drought, cheaper foreign competition, fashion, etc. Plants may be propagated by seeds, but often desirable cultivars are propagated asexually by budding, grafting, layering, or other nursery techniques.

Nurseries often grow plants in a greenhouse, a building of glass or in plastic tunnels, designed to protect young plants from harsh weather while allowing access to light and ventilation. Modern greenhouses allow automated control of temperature, ventilation and light and semi-automated watering and feeding. Some also have fold-back roofs to allow "hardening-off" of plants without the need for manual transfer to outdoor beds.

Most nurseries remain highly labor-intensive. Although some processes have been mechanized and automated, others have not. It remains highly unlikely that all plants treated in the same way at the same time will arrive at the same condition together, so plant care and horticulture nursery management require observation, judgment and manual dexterity. Selection for sale also requires comparison and judgment. It has been estimated that manpower accounts for 70 per cent of the production costs of a horticultural nursery.

**Types of Nurseries According to Type of Plants Grown**

**1. Fruit Plant Nurseries**

**Fruit Plants Nursery**

Fruit crops are mainly propagated vegetatively and need special techniques for propagations as well as maintenance. Mango, Guava, Pomegranate, Sapota, Oranges etc. are propagated with vegetative means. Fruit nurseries are essential for production of grafts as well as the mother plants of scions and rootstocks.

**2. Vegetable Nurseries**

All vegetables except few like potatoes, sweet potato, bulbous vegetables and some other are raised by seedlings. Very few vegetables are perennials like, little gourd,

drumsticks, Alocasia etc. Seedlings are to be produced on a large scale in short period.

**Vegetable Nursery**

### 3. Ornamental Plant Nurseries

Ornamental and floricultural crops are numerous and are propagated vegetatively, like gladiolus, carnation, roses, lilies etc. There is a large group of ornamental plants, which is propagated by seeds and seedling; Asters, Marigolds, Salvias, etc. are some of them.

**Ornamental Plant Nursery**

### 4. Medicinal and Aromatic Plant Nurseries

There is considerable increase in people adopting ayurvedic medicines with the changing life style. It is also necessary to conserve the fast depleting precious medicinal and aromatic plants. To save and multiply the valuable medicinal and other

auspicious plants, nurseries specializing in these plants have begun to flourish. These plants are also demanded by the Ayurvedic medicinal practitioners.

**Medicinal Plant Nursery**

5. **Forest Plant Nursery**
   Forest plants are essential for synthesis of gums, honey, timber and fuel. There is lack of forest plant nurseries. To save and multiply the entire lot of valuable forest plants it is very essential to preserve and multiply those plants for which special type of nurseries are to be established. This is also needed for medicinal purposes.

6. **Hi-Tech Nurseries**
   There is sudden increase in the demand for certain commercial plants. For example Tissue cultured banana, gerbera and carnation etc. It is not possible to fulfill this requirement by ordinary or common nursery practices. There is necessity to have special techniques and methods to meet the demand and only Hi-tech nurseries can satisfy this type of demand. These nurseries grow plants in greenhouse, building of glass or a plastic tunnel, designed to protect young plants from harsh weather, while allowing access to light and ventilation. Modern greenhouses allow automated control of temperature, ventilation, light, watering and feeding. Some also have fold-back roofs to allow "hardening-off" of plants without the need for manual transfer of plants to the outdoor beds.

**Types of Nurseries According to the Type of Sale**

1. **Retail Nurseries:** Retail nurseries raise plants for sale to the general public. These places are small, locally owned nurseries that sell seasonal, annuals, ornamental trees, other landscaping plants and garden decoration to the general public or companies

that specialize in a particular type of plant, such as tropical plants, citrus trees, bulbs or roses.

2. **Wholesale Nurseries:** Wholesale nurseries usually grow plants in bulk for the purpose of selling to large clients. These clients may include florists, garden centers or departmental stores. A wholesale nursery may fill a niche for particular types of plants, such as vegetables or houseplants, or they may grow a general selection of plants to sell such as fruits, vegetables and landscaping plants.

3. **Private Nurseries:** A private nursery grows plants exclusively for a single client. The private nursery may be owned by the client or it may be under contract for use by the client. Clients for private nurseries include large estates, corporations and institutions. These nurseries are concerned with raising documented historical plants for the historic preservation of the estates.

4. **Mail Order:** Privately owned, retail and wholesale businesses may all be involved in mail order businesses. As shipping technology improved, it became possible to ship dormant ornamental trees and bedding plants via mail. The internet has largely shifted mail order from catalog to online shopping. Bedding plants may be shipped via postal carrier, but are primarily handled through third-party shipping agents.

**Physical and Financial Resources for Nursery**

Nursery is the base for future development of Horticulture. Nursery can be a profitable venture only when it is thoroughly planned. Nursery depends on its physical resources as well as the financial resources. The physical resources include, land, water, labour and other supporting items such as transport, market communication facilities and availability of required technical know how. Second resource is finance. The capital requirement of a nursery should be fulfilled sufficiently and timely. There are several sources for finance, like, the banks, co-operative societies, personal loans, Govt. subsidies etc. It must be remembered that none of the above suffice 100 per cent requirement. Even though the budgets are planned, it takes much time to get the money in hand. It is therefore very essential to know these two aspects thoroughly.

Nurseries are highly labor-intensive. Although some processes have been mechanized and automated, others have not. It remains highly unlikely that all plants treated in the same way at the same time will arrive at the same condition together, so plant care requires observation, judgment and personal skill; selection for sale requires comparison and judgment. A high loss rate during maturation is accepted for the reduction in detailed plant maintenance costs. Nursery business is highly seasonal, concentrated in the winters and monsoon. The demand for the product is variable and is affected by temperature, drought, cheaper foreign competition, fashion, among other things.

Annuals are sold in trays (undivided containers with multiple plants), flats (trays with built-in cells), peat pots, or plastic pots. Perennials and woody plants are sold either

in pots, bare-root or balled. They are sold in a variety of sizes, from liners to mature trees. Balled and Burlap (B & B) trees are dug either by hand or by a loader that has a tree spade attachment on the front of the machine. Although container grown woody plants are becoming more and more popular due to the adaptability, B & B is still widely used throughout the industry. Plants may be propagated by seeds, but often desirable cultivars are propagated vegetatively by budding, grafting, layering, or other nursery techniques.

**(A) Physical Resources for Nursery**

Nursery like any other enterprise requires certain resources. The criteria for selection of products also depend on these resources. These resources thus play a very important role in determining the type of nursery enterprise. These physical resources are enlisted below,

**1. Land**

Land is the basic and fundamental physical resource for plant nursery. The area available must be considered before planning the nursery and the products. Soil sample testing should be done to avoid problematic and unmanageable soils. Soil should be well drained, porous and light to medium in texture. Soil pH should be 6.5 – 7.5. Heavy, black cotton soil, sandy, ill drained and soils having high pH more than 8 are strictly avoided. Low lying land should not be selected. The soils should be free from salts and other harmful elements. The selected site should be close to railway station or bus station. Wind breaks and shelter belts should be raised prior to planting nursery plants.

**2. Irrigation Facilities**

Required land with sufficient and assured supply of irrigation is the most important basic resource. Quality of irrigation water should be at prescribed level. Harmful factors can be tested by water testing in laboratory. The pH and electrical conductivity (EC) of irrigation water should be tested.

**3. Labour**

Labour is another important resource. Degree of mechanization must be considered before estimating the labor requirement. Skilled as well as unskilled man power is necessary for grafting, budding, weeding, irrigation, spraying, dusting, training, pruning, etc. Technically sound gardeners are also necessary. Labour should be available at reasonable rates.

**4. Electricity**

The availability of power or electricity is also very important and is in accordance with the man power available. Load shedding should be minimum possible. Regular supply of electricity is very essential. Electricity is required for water pumps, spraying, dusting and many other operations.

**5. Road and Transport**

Once the nursery stock is ready for sale, there should be good roads and transport facilities. These facilities are also required for timely importing of stock and other material for the nursery.

**6. Mother Plants**

Mother plants are the most important factor for successful nursery. Separate planting of mother plants is necessary. Different varieties of mother plants are planted in different plots. Pests and diseases are controlled regularly by spraying pesticides and fungicides. Mother plants should be authentic and selected from Government nurseries or from Agricultural Universities. Mother plants should be selected very carefully as the sale of the nursery stock depends on the mother plants used for the propagation.

**7. Propagation Structures:**

Propagation structures are very essential for production of grafts or seedlings. They are useful for multiplication of grafts and seedlings. Hardening of plants is done with the help of propagation structures.

**8. Hedges and Compound**

Thorny plants like Chilar (thorny creeper), golden duranta (thorny shrub), and agave are used as hedges in nurseries. Barbed wire fencing is also used. Hedges protect the nursery plants from wild and stray animals, theft, etc. They fix the borders of the nursery and are ornamental and decorative.

**9. Space for Hardening of Nursery Plants**

Small shade net houses are required for hardening of nursery plants. Young, pampered seedlings that were grown either indoors or in a greenhouse will need a period to adjust and acclimatize to outdoor conditions, prior to planting. This transition period is called "hardening off". Hardening off gradually exposes the tender plants to wind, sun and rain and toughens them up by thickening the cuticle on the leaves so that the leaves lose less water. This helps prevent transplant shock in which the seedlings have a stunted growth or they die from sudden changes in temperature. Hardenings off time depend on the type of plants grown and the temperature fluctuations.

**Hardening of Nursery Plants**

**10. Store and Office**

Garden tools, implements, raw materials, insecticides, fungicides, manures, fertilizers, boards, polythene bags etc are stored in store house. An ideal nursery has at least one well managed office for keeping all registers, notebooks, information books and for instructing the team. The record of mother plants, progeny, Stock of plants, etc is preserved in office.

**Types of Plant Nursery Soil**

Nurseries grow plants for resale to landscapers and to the general public. A nursery can be a field nursery where plants are grown in the soil, a container nursery where all the plants are grown in pots or a greenhouse operation where the plants are grown in different types of growth media. The type of soil needed for nursery production will depend upon what and how you intend to grow. Growing media such as peat or bark are often used in container and greenhouse nurseries to reduce the pest and disease problems.

**1. Field Nursery Soil**

Field nurseries mainly produce ornamental shrubs, fruit trees and perennial flowering plants. The type of soil needed for a field nursery needs to be fertile and well drained. The soil should cling to the roots of the plants well when the seedlings/grafts are transplanted and the root ball is covered with burlap for shipment.

The top soil should be enriched with compost and manure to maintain fertility and soil structure. The root ball size should be kept as small as possible to minimize topsoil loss. Short duration cover crops may be taken on fallow areas to improve soil tilth by minimizing erosion.

**2. Container Nursery Soil**

Container nurseries grow plants in containers. Some containers are pot-in-pot where plant containers are placed in permanent ground containers called socket pots. These are usually used to grow trees or large shrubs. Smaller plants and shrubs are grown in pots above the ground. Good drainage is necessary for container grown plants. A mixture of sand, peat moss and aged hardwood bark is commonly used for pot mixture. Lime often needs to be added to the non-soil growth media to balance its pH. Additional nutrients and minerals such as sulphur may also be needed.

**3. Greenhouse Nursery Soil**

A greenhouse nursery uses a combination of growing media to grow plants. In the greenhouse aeration and drainage are important considerations. Sand and organic growth media such as hammered bark and sphagnum peat moss provide good support for young plants without exposing them to the disease and pest risks found in topsoil.

**Legal Authorizations for Starting Nursery Business**

A commercial nursery business requires a business license which is a rather lengthy process. In many cases zoning ordinances dictate possible uses for land. Normally, a nursery business would be considered an "agricultural use", but in some cases it may also

be interpreted as “commercial", "agribusiness", or some other classification. Permits regarding establishment of green houses must be taken before erection of a green house, storage building or warehouse for storing materials and equipment required in a nursery. A nursery business may require a property hazard insurance, workmen's compensation if you have paid employees and general liability insurance if you expect visitors to your nursery. Nurseries in some areas may have to fulfill the government agricultural inspection requirements as per the body governing the area. Permissions are also required from the local authorities for availing electricity, water and other facilities.

**Investigation of Potential Market for Plant Nursery**

1. Nurseries under Horticulture Board Development Programs sponsored by State Agricultural Departments, Medicinal Boards, etc. produce plants for home gardens, landscaping, reforestation, and other uses. It should be decided as to which type of plants the nursery would produce, like the container grown, bare root, or root balled plants, etc.
2. Production of sufficient quantities of good quality material in order to satisfy the customer needs is essential. While producing more than the requirement may lead to unsold surplus which may cause losses to the nursery unit.
3. Advertising is costly but effective in horticulture nursery business. Marketing and advertising strategies must be preplanned to support each other and the business.

**Site Selection for a Nursery**

The site land should be suitable for nursery purpose. It must be laid out appropriately. It is also necessary for the site to have a good access for customers to reach the nursery.

**Some Other Resources Required:**

1. **Seeds/Seedlings/Saplings/Budlings:** The best quality pure planting materials are brought from authorized and well known sources.
2. **Containers:** This may simply be "peat cups" for seasonal vegetable or flower nurseries, or plastic pots and containers for growing potted shrubs and ornamental trees.
3. **Landscape Fabric, Mulch, and Soil Conditioners**: These resources are also required in nursery business and made available by registered stores.
4. **Equipment and Implements:** The various equipments and implements are required in a horticultural nursery. These may be bullock-drawn; man-operated or power-driven. One should not depend on a single type of power. Small tractors with suitable trolleys, spray pumps, dusters, sprinklers, cranes, etc are very useful in nursery operations. These facilities can be bought, borrowed or hired on contract as and when needed. But the hiring, borrowing and sale agencies should be nearby and reliable.
5. **Education and Knowledge:** Educating oneself about the local growing conditions and the probable problems which may come up in the future must be considered and taken care of prior to venturing into the nursery enterprise. Interactions with the local landscapers and entrepreneurs could help to find out what items are in demand in the specific area. There are "staple" plant products commonly used in an area, but these

are commonly available with all nurseries. The most unusual plants which are being requested must also be considered. Indigenous species which could be used as garden plants should be considered as they can be acclimatized with minimum environmental impact. A detailed study of the plant species to be grown and the time required for their growth in order to be ready for the market must be studied. Ornamental plants grow fairly fast in the right conditions, but they may still take a year or more to be ready for market. Trees may take 3 to 5 years, depending on the size and species, when propagated from seed.

**(B) Financial Resources for Nursery**

**Bank Loans**

Terms and conditions differ from bank to bank, state to state and again the procedure for release of first installment is delayed. This may put the nursery unit in loss or trouble.

**Financial Resources from Government**

National Horticulture Mission (NHM) started in 2005 in India with an objective to establish ideal nurseries for production of genetically pure plant materials. Nurseries in the public sectors (on government establishments) are entitled to get 100 per cent subsidies on expenditure. The nurseries in the private sector get a subsidy of 50 per cent on their expenditures.

There are two types of nurseries based on their sizes. Big nurseries are those with size of 1 hectare area. Such nurseries are entitled to receive financial assistance up to 30 Lakh as subsidy. The small nurseries with size of 1 Acre are entitled for a subsidy up to 18 Lakhs. The subsidies are given as per the bank loans sanctioned.

**Financial Resources from Nationalized Banks**

There are different schemes under National Horticulture Mission for establishment of horticulture nurseries:

1. Development of Orchard with Tools and Implements
2. Establishment of New Orchards
3. Sources of Irrigation Facilities
4. Controlled Farming
5. Integrated Pest Management/ Integrated Disease Management
6. Organic Farming
7. Human Resource Development
8. Practicals on Technology
9. Honey Bee Keeping
10. Post Harvest Handling of Fruits and Vegetables.
11. Self Employment Program.

**Financial Resources from Private Sector**

There are various private financing institutes funding the establishment of horticultural nurseries. Private Credit Co-operative Societies also extend loan facilities to nurseries.

## 1.2.5 Mother Plant Selection and Maintenance

Mother plant is the most important factor of plant nursery. Mother plants provide bud sticks and scions for budding and grafting operations.

**Criteria for Selection of Mother Plants**

1. Mother plants should be vigorous, healthy and high yielding. It should have a regular bearing habit.
2. It should be free from pests, diseases and viruses.
3. The mother plants must necessarily be genetically pure and superior in quality. They must be obtained from Registered Farms, Agriculture Universities or Government Nurseries.
4. The purchase receipt of mother plant should be preserved to prove the origin and authenticity of the mother plants.
5. Mother plants should be selected corresponding to the regional demand of the nursery plants.
6. Ornamental mother plants are planted under protected conditions either under shade net or semi-shade conditions.

**Planting of Mother Plants**

Proper selection is very necessary for mother plants. By considering its quantitative and qualitative characters, mother plants are selected and planted in nursery. They are planted according to the recommended planting distance. Care should be taken that the mother plants attain optimum vegetative growth. Mother plant plantation must be well classified according to the types and varieties. Ornamental mother plants are planted under poly house or shed nets.

**Some Important Mother Plants and their cultivars for Maharashtra and South India**

| | |
|---|---|
| 1. Mango: | Keshar, Alphonso, Sindhu, Ratna |
| 2. Sapota: | Kalipatti, Cricket ball |
| 3. Guava: | Sardar (L-49) |
| 4. Pomegranate: | Ganesh, G-137, Bhagawa |
| 5. Ber: | Umran, Kadaka, Sannur, Punjab Chouhara, Mehrun. |
| 6. Cashew nut: | Vengurla – 4, 5, 6, 7 and 8 |
| 7. Coconut: | Banavali, T X D, Pratap |
| 8. Grapes: | Sonaka, Sharad Seedless, Thompson Seedless |

| | |
|---|---|
| 9. Fig: | Poona fig, Dinkar |
| 10. Aonla: | Banarasi, Krishna. |
| 11. Sweet orange: | Nucellar. |
| 12. Mandarin Orange: | Nagpuri |

**Maintenance of Mother Plant**

Mother plants are very important constituent of a nursery. The success of any nursery depends greatly on the health and vigor of its mother plants. It is therefore necessary to obtain genetically sound mother plants to produce healthy and vigorous offsprings. Not only is the selection of mother plants necessary but proper care and maintenance of these plants is also essential to obtain vigorous and healthy growth. This can be achieved by taking appropriate care. Mother plants are irrigated regularly. Manures and Fertilizers are given at proper stages. Diseases and pests are controlled by spraying fungicides and insecticides. After care and all operations are carried out so as to get healthy and vigorous bud sticks. First dose of manures and fertilizers is given in June – July. Second dose is given in September – October. Reproductive growth is strictly avoided. Only vegetative growth is permitted and maximum bud sticks are produced. Mother plants are kept healthy by regular testing of the plant material for viruses and other organisms. Register record about parents, pedigree and bearing habit is kept in office.

## 1.3 Glossary

**Dry Land Horticulture:** Plant Propagation and crop production in arid and semi arid region with annual rainfall less than 600mm.

**Floriculture:** Branch of Horticulture which deals with cultivation of flowers and ornamental crops.

**General or Common Nursery:** Plant Nursery where all type of seedlings and plants are produced on a large scale.

**Hi-tech Nursery:** Fully automated nursery in which all environmental factors are controlled and manipulated for production of healthy planting materials.

**Horticulture:** Branch of agriculture which deals with cultivation of garden and plantation crops, vegetables and ornamentals.

**Loan:** Capital in terms of money from financing agencies and institutions like banks and government schemes.

**Mechanization:** Nursery operations carried out with the help of machines.

**Olericulture:** Branch of horticulture which deals with cultivation of vegetable crops.

**Plant Propagation:** Multiplication of plants by using seeds or vegetative plant parts.

**Pomology:** Branch of horticulture which deals with cultivation of fruit crops.

**Skilled labour:** Labors having skills about grafting, budding, training, pruning etc.

**Tissue Culture Nursery:** Technique of vegetative propagation by using tissue under aseptic conditions with artificial media under laboratory conditions.

## 1.4 Points to Remember

- Plant propagation nurseries are basic units for horticulture production and development.
- To achieve the maximum uniformity in quality and production of nursery plants vegetative method should be adopted.
- The local and vicinity markets should be surveyed before establishment of a plant propagation nursery.
- Site selection for establishing a nursery is very important and all the factors related to site selection should be considered while establishment of plant production nursery.
- Procurement and establishment of mother plots should be undertaken well in advance and purity and quality should be ensured prior to establishment.
- Mother plot should be maintained properly and periodical inspection of mother plots should be carried out regularly.

## 1.5 Self Check Questions

1. Define a plant propagation nursery.
2. Enlist the factors considered in planning a nursery enterprise.
3. What are the major constraints in developing a nursery enterprise?
4. What should be the criteria for selection of a particular type of nursery?
5. What are the financial provisions to be made for a nursery enterprise?

## 1.6 Do it Yourself

1. Visit any well established private nursery unit. Enlist what are the plants grown and supplied to the public. Discuss with the owner and prepare a statement of income and expenditure and find out the cost: benefit ratio.
2. Visit a University or Government nursery. Perform the same exercise as proposed for the private nursery enterprise.
3. Prepare the plan of mother plots and enlist the steps to be taken to establish the mother plots and other sections in a big size plant propagation nursery.

# Unit 2: Plant Propagation Methods

***Index***



## 2.1 Introduction

Plant kingdom includes enormous types of plants. Some of them multiply by seeds while some by vegetative plant parts and some of them use both means for multiplication. One finds similarity or likeliness in characteristic of vegetative progenies while variation in sexually multiplied population.

Seed propagation is the major tool in crop production. Higher plants reproduce naturally by seeds. Seedlings are extensively used in nurseries to provide rootstocks upon which grafting or budding is done. In plant breeding, growing of seedling is the most important means of developing new cultivars. There are different techniques in seed production of fruit trees, vegetables, and ornamental plants. Production of hybrid seed is highly technical and time consuming process.

Vegetative propagation is called asexual propagation and has special importance in keeping uniformity amongst offsprings and obtaining early production. It is the only way of propagation in certain plant. Stock and scion both are important and vary according to need and convenience. Considerable skill at various stages during propagation and after care is highly necessary. This is the only method to establish a new orchard in situ, renovate old unproductive orchard or convert undesirable varieties into desired one.

**At the end of this unit, you will be able to know and understand:**

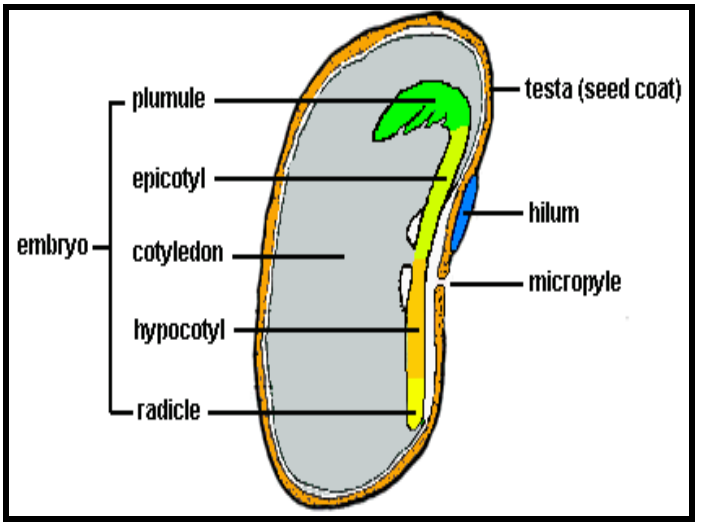
- Sexual method of plant propagation.
- Advantages and drawbacks of sexual method of plant propagation.
- Seed production techniques and seed certification.
- Germination and dormancy in seeds.
- Vegetative propagation in plants, its advantages and drawbacks.
- Various methods of vegetative propagation in nursery plants.
- Micro propagation of plants.

## 2.2 Contents

### 2.2.1 Sexual and Asexual Plant Propagation

**(A) Sexual Plant Propagation**

Sexual plant propagation involves the union of the pollen (male organ) with the egg (female organ) in plants to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself. When a mature seed is exposed to favorable environment, it germinates and begins its active growth.




**Structure of a Seed**

**Advantages of Sexual Plant Propagation**

1. It is the easiest and least expensive method of plant propagation.
2. Seedling trees are hardier and have longer life span.
3. Plants which are difficult to propagate by vegetative method e.g. papaya, phalsa, coconut etc. can only be propagated by seed.
4. The rootstocks on which the fruit varieties are budded or grafted are usually obtained by means of sexual propagation.
5. Sexually propagated plants are more resistant to pests and disease.
6. Large number of plants can be produced at a time by this method.
7. Polyembryonic varieties (give rise to more than one seedling from one seed) can be propagated by seed eg. Nucellar Embryo in Nucellar Mosambi (Sweet Orange)

**Disadvantages of Sexual Plant Propagation**

1. Seedlings take more time to bear fruits (late bearing).
2. Quality of existing plants cannot be improved by sexual propagation.
3. Plants propagated sexually are large in size, thus the cost of manuring, pruning and spraying increases.

4. In case of sexually propagated plants, there is no assurance about genetic purity of the offspring or seedling.

**(B) Asexual Plant Propagation**

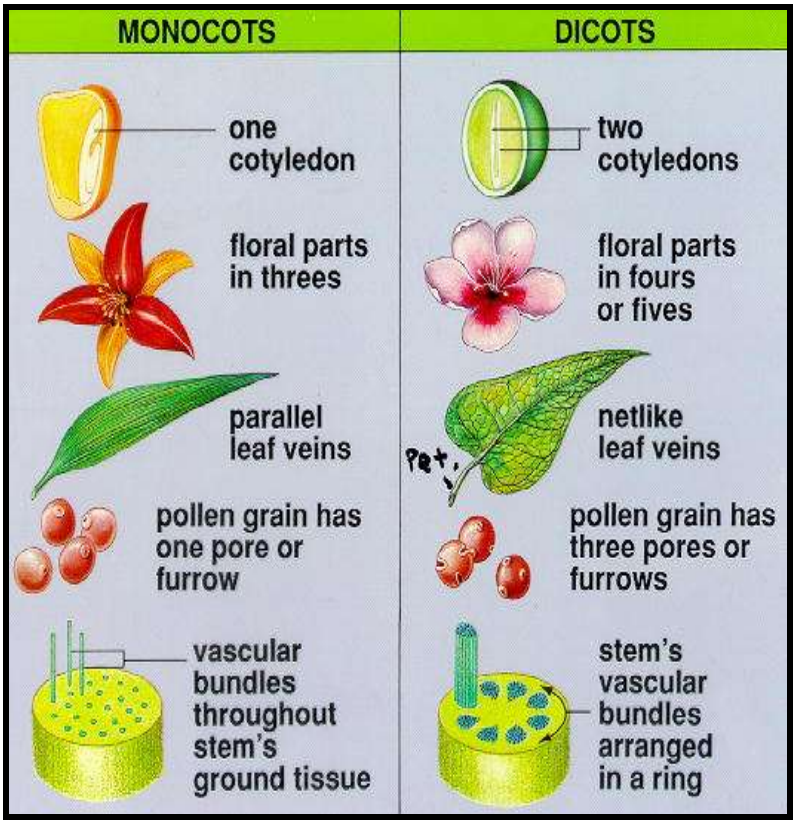
In this method the vegetative parts of plants such as leaves, stems, and roots are used for propagation. These plants may be taken from single mother plant or other plants. It is also called as vegetative method of plant propagation.

**Advantages of Asexual Plant Propagation**

1. Plants propagated by this method are true to type and uniform in growth, yield and quality of fruits.
2. Some fruits such as Banana, Pineapple, seedless Guava and seedless Grape varieties can only be propagated through vegetative means.
3. Vegetatively propagated fruit tree comes into bearing earlier than seed propagated plants and have assured genetic configurations.
4. Plants produced are of manageable size and have uniform fruits making harvesting easy.
5. Some diseases can be avoided in susceptible varieties by grafting them on a resistant rootstock e.g. Use of 'Rangpur Lime' as rootstock for budding Mandarin Orange to avoid gummosis disease.
6. Better rootstock can be conveniently combined with the method to suit the climatic requirement of the area.
7. Repairing of damaged portion of plant is possible by asexual methods through bridge grafting or buttressing. These methods can be used for healing of the wounds caused by rodents.
8. Inferior quality crown of the existing plants can be improved. For example, side grafting and crown grafting in mango.
9. It is possible to grow multiple varieties on the same plant. One can grow numerous varieties of Roses and Mangoes on different branches of the same stock.
10. Number of plant per hectare is more due to its small canopy and restricted growth.
11. Vegetative propagation helps in rapid multiplication with modern techniques like tissue culture and other micro propagation techniques.

**Disadvantages of Asexual Plant Propagation**

1. It is difficult and more expensive method of propagation in some plants like papaya, coconut, etc.
2. Plants are generally not so vigorous and long lived as seedling plants and they require special skill for propagation.
3. Hybridization in these plants is not possible because there is no variation in the progeny; these methods are not suitable for development of a new variety.
4. Plants propagated by this method are not hardy and fall easy prey to adverse conditions of soil, climate, diseases, pests, etc.




**Maize** **Beans**

**Difference between Monocot and Dicot Plants**

## 2.2.2 Seed Production and Seed Propagation

### (A) Seed Production

There are large numbers of crops which are propagated by seeds for which the seed production program plays a very important role. Basically there are two types of seeds i.e. monocots and dicots. Seed is the basis for sexual propagation. Apomixes and polyembryony are also important though they are not common.

### Objectives of Seed Production

The scientific seed production consists of various activities from selection of seed source, crop production, harvesting, processing, storage and distribution. The objectives of seed production can be summarized as follows.

1. **High Agricultural Production**
   The main object is to secure higher production by growing improved seed of promising varieties. The scientists have estimated that agricultural production can be increased by 20 per cent by efficient quality seed.
2. **Rapid Multiplication**
   Seed of an improved variety can be generated in single season or year. It is generated in several stages. Therefore, in order to meet huge demand, the improved

seed should be multiplied in adequate quantities in minimum time after the release of the variety.

3. **Timely Distribution**
   It is necessary for the multiplied seeds to reach to the farmes just in time of sowing. The effective seed supply depends upon the factors such as place of production, transportation, storage facility and marketing channels, etc.
4. **Seed Quality**
   The quality of seed is an important parameter for obtaining the estimated production and profit. It should be maintained during all the stages of seed production. In short the seed should possess good genetical and physical characters.
5. **Reasonable Price**
   The cost of quality seed should be reasonable and affordable to the farmers.

**(B) Seed Certification Process**

Plant breeders bring about improvement in the various varieties by importing new genes that fit the conditions better. The improvements include, disease resistant, high yielding, more attractive, easier to breed, etc. Once the plant breeder has completed the breeding program and tested the new material extensively, the seed is then released by the plant breeder into special procedures for propagation.

Before the variety becomes available for ordinary grower, it goes through stages of multiplication and certification. According to the stages, there are four classes of seed.

1. **Breeder Seed**
   A small amount of seed is developed and released by a plant breeder as the source of foundation seed.
2. **Foundation Seed**
   Breeder seed is multiplied under supervision of agricultural research stations and monitored for genetic purity and identity.
3. **Registered Seed**
   Foundation seed is distributed to certified seed growers to be further multiplied for distribution.
4. **Certified Seed**
   The progeny of registered seed is sold to farmers. During the process of multiplication, certifying agencies in the state or region of production monitor the activity to insure that the product meets standards set for the crops.

**(C) Seed Multiplication:**

There are large numbers of crops which are propagated by seeds for which the seed production program plays very important role. However, seeds can be classified into 2 major groups, i.e. monocots and dicots.

Hybrid varieties have become an increasingly important category of cultivated plants in recent years. In India, all older varieties in tomato, cucurbits, melons and many others have been replaced by new high yielding hybrids. Once the seeds are procured and planted, great care for seedlings is important. It is necessary to closely follow all the instructions while harvesting seeds of herbaceous plants, dry seeds and fruits, seeds from

fleshy fruits and also the tree and shrub seeds. The seed are collected at proper stage, Extraction and separation of seeds are done and then are processed for further storage – open storage with temperature control, warm storage with moisture control, cold storage with or without moisture control and cold, moist storage are some storage methods.

**Seed Quality**

Quality plants are produced only from quality seeds obtained from a reliable dealer. Select varieties to provide the size, color, and growth of plant. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than non-hybrids and sometimes have specific disease resistance or other unique cultural characteristics. Some seeds can be stored for several years if stored properly. But it is advisable to purchase seeds required for a single planting year. The seed material which does not contain the seeds of any other crop, weed seeds, or other debris is considered to be good. Printing on the seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, and germination percentage you may typically expect, and suggestions regarding any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date they must be stored in cool, dry places. Laminated foils packets help ensure dry storage. Paper packets are best kept in tightly closed containers and maintained around 4° Celsius temperature and low humidity.

**Seed Germination**

There are four environmental factors which affect germination: water, oxygen, light, and heat.

1. **Water**: The first step in the seed germination process is the absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure seed germination. Once the seed germination process has begun, a dry period will cause the death of the embryo.
2. **Light:** Light is known to stimulate or inhibit germination of some seed. The light reaction involved here is a complex process. Some crops which have a requirement for light to assist seed germination are Ageratum, Begonia, Browallia, Impatiens, Lettuce, and Petunia. Conversely, Calendula, Centaurea, annual Phlox, Verbena, and Vinca germinate best in the dark. Supplemental light can also be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day.
3. **Oxygen**: Respiration takes place in all viable seeds. The respiration in dormant seed is low, but some oxygen is still required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well-aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.

4. **Heat**: Favorable temperature is another important requirement for germination. It not only affects the germination percentage but also the rate of germination. Some seeds germinate over a wide range of temperatures, whereas others require a narrow range. Many seed have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of $10^{o}$ Celsius and a maximum temperature of $35^{o}$ Celsius. But the optimum germination temperature is about 25 to $27^{o}$Celsius. Generally, $18^{o}$ to $24^{o}$Celsius temperature is the best for germination of many plant seeds.

**Methods of Breaking Dormancy**

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

**Seed Scarification**

Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter to stimulate the seed germination process. There are several methods of scarifying seeds. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat becomes loose, the seeds can be removed, washed, and planted. Another scarification method is mechanical. Seeds are filed with a metal file, rubbed with sandpaper, or cracked with a hammer to weaken the seed coat. Hot water scarification involves putting the seed into hot water at a temperature of $75^{o}$ to $100^{o}$Celsius.

**Seed Stratification**

Seeds of some trees and shrubs of the temperate zone do not germinate unless they are exposed to chilling temperatures. This can be accomplished artificially by a practice called stratification.

The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 2-3 cm from the top. Place the seeds on top of the medium and cover with 1 cm of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator. Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag from the refrigerator. Take the pot out and set it in a warm place in the house. Water often enough to keep the medium moist. When the young plants are about 5-7 cm tall, transplant them into pots to grow until time for setting outside.

## 2.2.3 Vegetative Propagation

Vegetative Propagation is the formation of new individuals from the cell(s) of a single parent. It is very common in plants; less so in animals.

**Importance of Vegetative Propagation**

When the seed fails to regenerate, vegetative propagation is the only method for regeneration in such plants. Vegetative propagation has advantages such as earliness, uniformity as well as similar phenotypes over seed or sexual regeneration. 'True to type' is the characteristic of vegetatively propagated population. Vegetative propagation practices are carried out in propagation structures such as polyhouse, shade net, green house, mist house, potting shades, tissue culture labs and hardening room have improved efficacy. Media other than ordinary soil are used for rooting or initial growth of saplings /seedling etc. Nursery soil, finely ground farm yard manures, sphagnum moss, sand, sawdust, vermiculite; charcoal powder, peat moss, and coco peat are some of the important media used in nurseries for commercial production of important horticultural crops. Many horticultural crops can be propagated by more than one method in such case, the most effective and economic method is to be adopted.

**Limitations of Vegetative Propagation**

1. Plants like coconut & arecanut are difficult to propagate vegetatively.
2. Hybridization is not feasible in vegetative propagated generations of plants.
3. High skill and time are required in vegetative propagation of plants.

**Types of Vegetative Propagation**

**A. Vegetative Propagation by Using Underground Plant Parts**

i.e. Root, Corms, Bulbs, Rhizomes, etc.

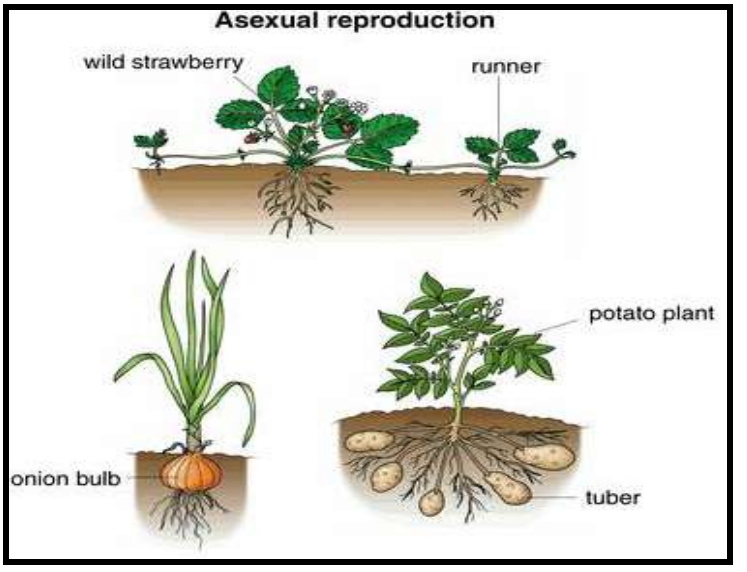
**B. Vegetative Propagation by Using Above Ground Vegetative Plant Parts**

1. Vegetative Propagation by buds.
2. Vegetative Propagation by leaves
3. Vegetative Propagation by tissues
4. Vegetative Propagation by cuttings: a. Hardwood cuttings, b. Semi hardwood cuttings, c. Softwood cuttings, d. Herbaceous plant part
5. Vegetative Propagation by layers: a. Air Layers, b. Tongue Layers, c. Ground Layers, d. Mound Layers, e. Trench Layers.
6. Vegetative Propagation by buds: Patch buds, b. Ring buds, c. Forkert buds, d. 'T' buds.
7. Vegetative Propagation by grafting: a. Approach grafting, b. Stone grafting, c. Veneer grafting, d. Side grafting

**Vegetative Propagation in Plants:** Plant organs used for asexual reproduction are,

**Stems:** In some species, stems (stolons) produce roots at their tips forming a new plant. The horizontal above-ground stems (called stolons) of the strawberry produce new daughter plants at alternate nodes.

**Roots:** Some plants use their roots for asexual reproduction. Trees, such as the poplar or aspen, produce new stems from their roots which bear leaves as well as branches.




**Asexual Reproduction by Runners, Bulbs, Tubers**

**Leaves:** The common ornamental plant Bryophyllum reproduces with tiny plantlets produced on the leaf margins. Mitosis at meristems along the leaf margins produce tiny plantlets that fall off and can take up an independent existence.

**Reproduction by Leaves in Brayophyllum**

## Media for Vegetative Propagation

There are several media and media mixtures that are available for use in propagation particularly for rooting and growing of container plants.

**Characteristics for Good Media**

The growth media should have the following characteristics for good results.

1. The growth medium must be sufficiently firm to hold the cutting in place during rooting. The volume must be fairly constant when it is dry or wet.
2. It must be sufficiently retentive of moisture so that frequency in watering can be minimized.
3. It must be porous so that excess of water can be drained out.
4. The media should be free from weed seeds, pathogens, termites, nematodes etc.
5. The media should be capable or suitable for getting sterilized without any ill-effects.

**Some Important Media**

1. **Soil:** Soil is a very common easily available and comparatively cheaper medium used in nursery. The soil contains both organic and inorganic matters. The organic part is the residues of living and dead parts of plants, animals, and microbes. The liquid part of the soil is the soil solution containing water, dissolved minerals as well as $O_2$ and $Co_2$. The gaseous portion of the soil is important to keep the balance of air and water in proper and desired condition. The texture of the soil depends on the relative proportions of sand, silt & clay. Depending on three proportions, soils are classified as Sandy, Loamy Sand, Sandy Loam, Silt Loam, Clay Loam and Clayey soils. The soil structure refers to the arrangement of their particles in the soil mass. The nursery soil must have a good texture and structure.
2. **Sand:** Sand is the result of weathering effect on parent rocks. The usual size of sand is from 0.05 to 2.0 mm. Sand is generally used in plant propagation media. The sand used in plastering is very much suitable for rooting of cuttings. The sand should be heated or fumigated before being used as media. Generally sand does not contain any mineral nutrients and has no buffering capacity.
3. **Peat:** Peat consists of the residues from a marsh swamp. Vegetative peat moss is available but should be broken into fine parts before used in mixtures or as media. It contains some organic nitrogen and is favorable for newly rooted cuttings or germinated seeds.
4. **Sphagnum Moss:** Sphagnum moss is the dehydrated remains of acid hog plants and has three genera, growing naturally in damp humid forest lands. It is relatively sterile, light in weight and has a very high water holding capacity. Normally, it absorbs and holds water 20 times to its weight. Sphagnum is acidic in nature having pH about 3.5. It also contains a fungistatic substance which is useful to inhibit damping off. Moss is soaked in solution containing fungicide and is impregnated with nutrient solution before being used for propagation. It is used for air layering in woody perennials like pomegranate and figs.
5. **Vermiculite:** This is the micaceous mineral which expands significantly when heated. Chemically it is hydrated magnesium, aluminum, iron, silicate. When expanded it is very light in weight. It is neutral in reaction and has good buffering properties. It is insoluble in water. Vermiculite is available in 4 Grades, out of which

the Horticultural Grade No. 2 should be used for rooting and No. 4 for seed germination.

6. **Perlite:** This is gray white material having volcanic origin. It is neutral. It has no buffering reaction and it contains no mineral nutrients.
7. **Leaf Mold:** It is prepared by using fallen leaves of various tree species available locally, eg Oak, Silver oak, Maple, Azadirachta, Ficus, etc. it is prepared by stacking a few layers of leaves then covering them with a thin layer of soil and cow dung slurry. Some live culture of decomposing organisms is added to hasten the process of decomposition. The medium is ready for use after about 12 to 18 months of decomposition.
8. **Saw Dust:** It is a byproduct or waste material from saw mills. The quantity and quality depend on the parent wood material. It is mixed while preparation of media.
9. **Grain Husk:** Several type of husks are available, paddy husk is one of the important wastage from rice mills. It is light in weight and cheaply available. It is suitable for mixing with other types of media.
10. **Coco Peat:** Coco peat, cow dung etc. are also used as media. A mixture of few media is always preferred and used in commercial nurseries. Many times soil is one of the main parts for mixtures. Media must be selected on the basis of the availability, cost, ease in handling etc. The media should be procured and stored and kept ready for use in nursery.

**Coco Peat: Soil-less medium used in Nursery**

## 2.2.4 Budding, Layering and Grafting in Horticulture

### (A) Budding

It is the vegetative method of plant propagation and can be defined as an art or technique of inserting a single matured bud taken from a desired tree in the rootstock, in such a way that the union takes place, bud sprouts and the combination continues to grow. When scion part is small piece of bark containing single bud, the operation is called as budding.

**Scion**

Scion is the part of mother plant used in budding and grafting to develop the fruit tree. It is an upper portion of the composite plant which forms the fruit bearing part of the tree.

**Rootstock**

It is the part of the original tree on which the scion is worked upon to produce the desirable tree. The scion and rootstock from separate mother plants are considered for budding purpose.

**Aonla: Stock (base) and Scion (top)**

**Methods of Budding**

**1. T-Budding**

T-budding must be done when the bark is succulent and in slipping condition. When cut, the bark easily lifts or peels in a single uniform layer from the underlying wood without tearing this is 'Slipping'. The exact time when this condition occurs depends on soil moisture, temperature, and time of year. It varies with species and variety. Dry, very hot or very cold weather can shorten the period of bark slipping. Irrigation can be valuable in extending the T-budding season.

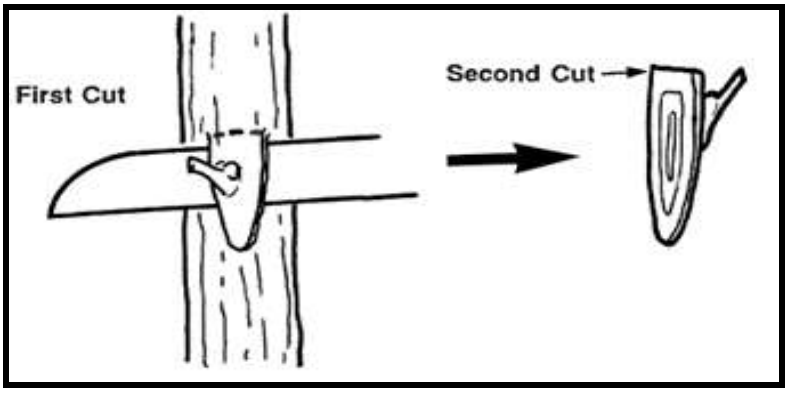
The successful budding operation can be obtained when the following precaution is taken. Buds should not be inserted when the air temperature exceeds 32.2$^{o}$C.

**Preparing the Stock:** Budding knives usually have a curved tip, making it easier to cut a T-shaped slit. First, insert the point of the knife and use a single motion to cut the top of the T. Then without removing the point of the knife, twist it perpendicularly to the original cut and rock the blade horizontally down the stem to make the vertical slit of the T. If bark is slipping properly, a slight twist of the knife at the end of this cut will pop open the flaps of the cut and make it easier to insert the bud. In practice, the top of the T is usually slanted slightly.

This same type of cut can be made using two separate strokes, one vertical and one horizontal, and then using the back of the budding knife tip to pry up the flaps slightly. Although much slower, this technique may be easier to practice.

**Removing Buds from the Bud Stick:** The bud to be inserted is often just a shield of bark with a bud attached or a very thin layer of wood with both the bark shield and bud attached. Various techniques can be used to make these cuts, but the shape of the cut remains the same.

Begin the first scion cut about 1 cm below the bud and draw the knife upward just under the bark to a point at least 0.50 cm above the bud. Grasp the petiole from the detached leaf between the thumb and forefinger of the free hand. Make the second cut by rotating the knife blade straight across the horizontal axis of the bud stick and about 1/4 inch above the desired bud. This cut should be deep enough to remove the bud, its shield of bark, and a thin layer of wood.




**Removing Shield of Bark with the Bud Attached**

A variation often used with budwood is to slant the first upward cut so that it goes about halfway through the bud stick. Then make the top cut and bend the bud stick by applying gentle but constant finger pressure behind the bud. The bark should lift and peel off to the side, yielding bark and bud but not the wood.

**Inserting the Bud:** Insert the bud shield into the T flaps of the stock and slide it down to ensure that it makes intimate contact with the rootstock.

**Removal of Bud**

**T Shaped cut on the Rootstock**

**Inserting the Bud**

**Securing the Bud with Polythene**

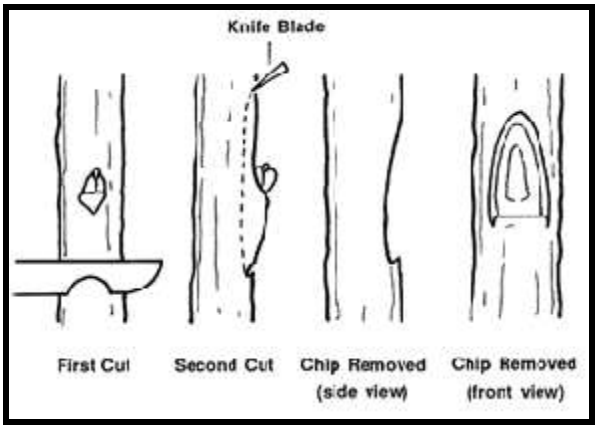
**Bud and stock Joint**

**Securing the Bud:** Pull the cut together by winding a 10 to 12 cm long polythene strip around the stem to hold the flaps tightly over the bud shield and prevent drying. Secure the polythene strip by overlapping all windings and tucking the end under the last turn. Do not cover the bud.

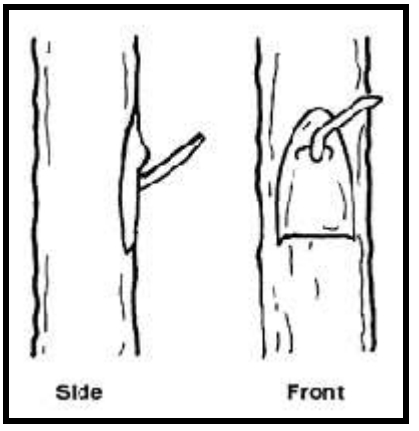
**(B) Chip Budding**

Chip budding is a technique that may be used whenever mature buds are available. Because the bark does not have to "slip," the chip-budding season is longer than the T-budding season. Species whose bark does not slip easily without tearing may be propagated more successfully by chip budding than by T-budding.

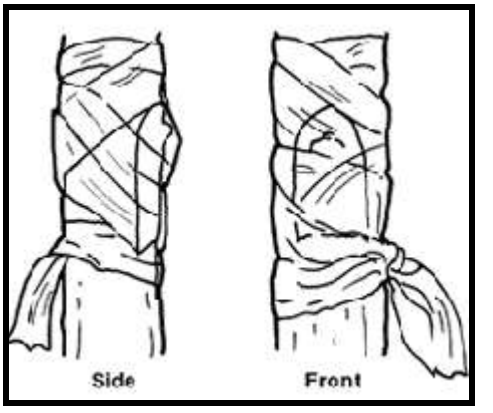
**Preparing the Stock and the Scion Bud:** Although all the basics in handling bud wood and stock are the same for chip budding and T budding, the cuts made in chip budding differ radically. The first cut on both stock and scion is made at a $45^{o}$ to $60^{o}$ downward angle to a depth of about 3 mm. After making this cut on a smooth part of the rootstock, start the second cut about 2 cm higher and draw the knife down to meet the first cut. Then remove the chip.




**Removing the Chip**




**Inserting the Bud**




**Securing the Bud**

Cuts on both the scion (to remove the bud) and the rootstock (to insert the bud) should be exactly the same. Although the exact location is not essential, the bud is usually positioned one-third of the way down from the beginning of the cut. If the bud shield is significantly narrower than the rootstock cut, line up one side exactly.

**Securing the Bud:** Wrapping is extremely important in chip budding. If all exposed edges of the cut are not covered, the bud will dry out before it can take up. Chip budding has become more popular over the past few years because of the availability of thin polyethylene tape as a wrapping material. This tape is wrapped to overlap all of the injury, including the bud, and forms a miniature plastic greenhouse over the healing graft.

**Budding Aftercare:** When irrigation is available, apply water at normal rates. Ornamental peaches and pears often will break bud and grow the same year they are budded. The polyethylene tape needs to be removed after the bud has completely healed and sprouted into vegetative flushes. Summer buds take 2 to 3 weeks for sprouting.

## (C) Layering

Layering is a method of vegetative propagation by which a good stem is induced to produce roots while it is still attached to the parent plant. In this manner a new plant usually can be developed in a relatively short time and with less trouble than other methods of propagation. It can be used successfully on many fruit trees and woody ornamental shrubs grown.

### 1. Air Layering

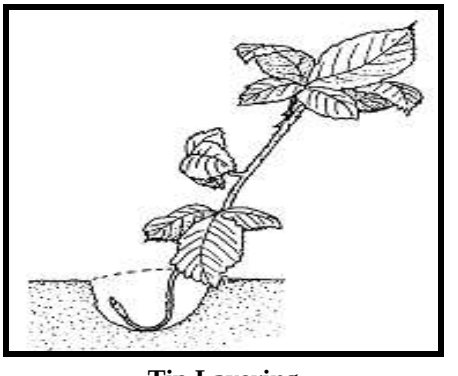
Best results are obtained when young, vigorously growing healthy shoots are selected for layering. The leaves on selected shoots should be exposed to light since these produce more food and will root faster. Shoots from 0.5 to 2 cm in diameter are best for air layering. Materials needed are a sharp knife, two handful of damp sphagnum moss, a 15 x 20 sq.cm sheet of polyethylene film, rubber bands or pieces of twine, and a 15 x 20 sq.cm sheet of either craft paper, cloth or aluminum foil. The first step is to remove leaves and twigs on the selected shoot 7 to 10 cm above and below the point where the cut is to be made. Next, injure the branch with a knife and wrap it in a warm moist medium. This stimulates the formation of new roots from the injured area.

Two methods of injuring the shoot can be employed and both produce satisfactory results. One method consists of removing a 1 to 2 cm ring of bark from the shoot by making two circular cuts. After removing the bark, expose the wood to be sure that the cambium layer, (a light green area immediately beneath the bark) is completely removed. This will prevent callus formation and allow roots to be initiated. For the second method, a long slanting upward cut is made about 0.5 to 1.0 cm through the stem and the incision is kept open by inserting a small chip of wood. The upward cut method is used on plants where the bark does not peel off easily. Dusting the wound with a rooting hormone may hasten rooting on some hard-to-root plants but does not produce more or healthier roots than an untreated cut.

After removing the bark or making the cut, enclose the injured area in a ball of moist sphagnum moss as soon as possible. Make sure that the excess moisture is squeezed out before applying it to the cut surface. Plants commonly propagated by air layering include the Rubber plant, Hibiscus, Calliandra, Oleander, Screw Pine (Pandanus), Gardenia, Croton and Bougainvillea.

**2. Tip Layering**

Many plants with drooping or viny growth habits can be propagated by tip layering. A low branch or one that can be bent easily to the ground is selected. It is injured (or scored) either by ringing, or slicing a cut 15 to 20 cm from the tip of the branch. The injured area is anchored in the soil deep enough to remain moist but the leafy tip is left above ground.



**Tip Layering**

To keep the area moist, peat moss may be added to the soil and used as mulch. Climbing roses, Primrose, Jasmine, Oleander and Bougainvillea can be propagated by tip layering.

**3. Trench Layering**

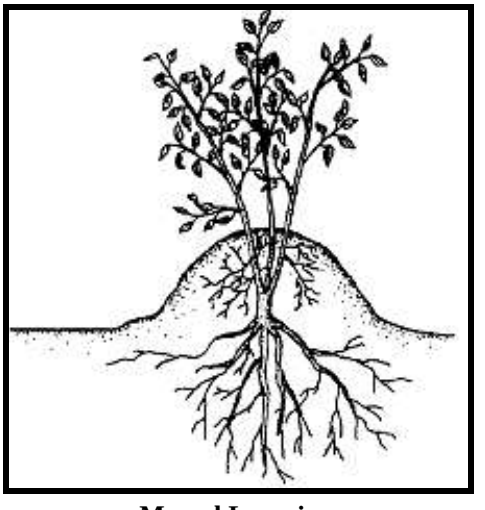
This method is an adaptation of tip layering and produces several plants instead of one. A branch of current season's growth which can be easily bent to the ground is chosen and all the leaves except those at the tip and on the lateral branches are removed. The laterals are pruned back to two or three buds. The limb is then placed in a small trench and when the buds begin to grow, all the tips of the main limb and laterals are

covered with about 10 to 15 cm of soil. Roots will form at each node and a new plant will develop. Rooting can be hastened by making a shallow cut below each bud. The time required for rooting varies with the type of plant and moisture conditions. As soon as the roots develop and the buds begin to grow, the layers can be separated from the parent plant and potted. Passion fruit and jasmine can be layered by this method.

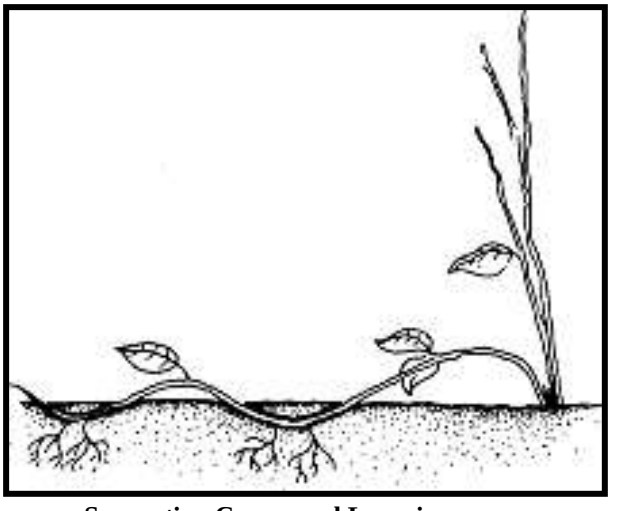
**4. Mound Layering**

This method is used to propagate many of the thick stemmed or closely-branched plants especially when it is desirable to root all the branches. In cases where shrubs have been severely cut back to the ground, mound layering can also be used to propagate new plants. In general it is best to cut the plant back severely during the previous season to force new shoots close to the ground and around the center of the plant. The shoots should first be injured, as in tip layering. The soil is then mounded up around the base of the plant again and some peat sphagnum moss mixed with the soil.

After rooting, branches can be separated as with individual plants in tip layering, cut below root line and either potted or transplanted. Plants commonly propagated by this method include Aralia, Croton, Calliandra and Glorybush (Tibouchina).



**Mound Layering**



**Serpentine Compound Layering**

**5. Serpentine Compound Layering**

This method is best adapted to ornamental vines and plants with pliable stems. It is a variation of trench layering in which alternate buds or nodes are buried and left above ground. Any long stem close to the ground can be used. Rooting is also aided by making shallow cuts below each node that is buried. The covered portions can be held in place by a bent wire or stones. Individual plants will then be removed by cutting below the rooted area.

Serpentine layering is used in the propagation of plants such as Grape rootstocks, Virginia creeper and many other vines. Plants that can be propagated by layering are Passion Fruit, Barbadine (granadilla), Jasmine (Tibouchina), Bougainvillea, Crotons, etc.

**(D) Grafting**

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially.

In most cases, one plant is selected for its roots, and this is called the rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion. The scion contains the desired genes to be multiplied in future production by the compound stock and scion combined plant.

In stem grafting, a common grafting method, a shoot of a selected, desired plant cultivar is grafted onto the stock of another type. In another common form called budding, a dormant side bud is grafted on the stem of another stock plant, and when it has fused successfully, it is encouraged to grow by cutting out the stem above the new bud.

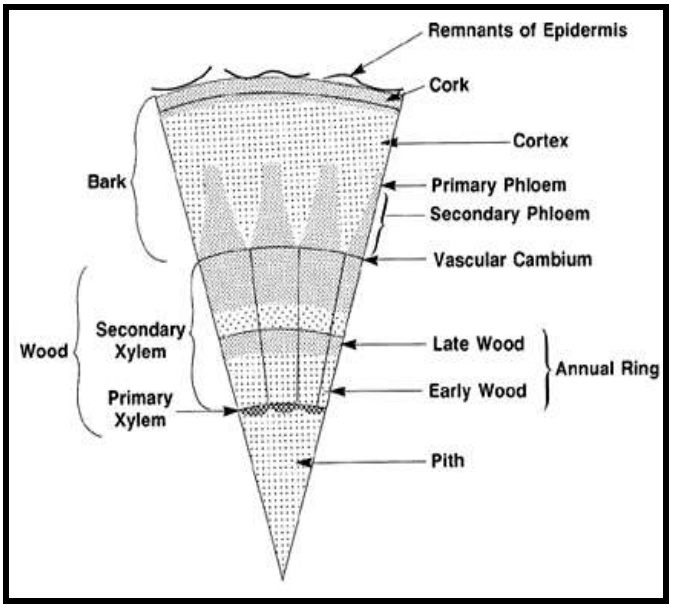
For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has taken, usually a period of a few weeks. Successful grafting only requires that a vascular connection take place between the two tissues. A physical weak point often still occurs at the graft, because the structural tissue of the two distinct plants, such as wood, may not fuse.

**Selecting and Handling Scion Wood**

The best quality scion wood usually comes from shoots grown in the previous season. Scions should be severed with sharp, clean knives and placed immediately in moistened plastic bags. It is good practice to clean the cutting tools regularly. This may be done by flaming or immersing them in a sterilizing solution. Ethyl alcohol also works well as a sterilant, although it evaporates quite readily. An alternative sterilizing solution may be prepared by mixing one part household bleach with nine parts water. However, this bleach solution can be highly corrosive to certain metals.

For best results, harvest only as much scion wood as can be used for grafting during the same day. Select only healthy scion wood that is free from insect, disease or physical damage. Be sure the stock plants are of good quality, healthy, and true to type. If large quantities of scion wood must be harvested at one time, follow these steps:

- Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
- Label them, recording the cultivar, date of harvest, and location of the stock plant.
- Wrap the base of the bundles in moistened burlap or sphagnum moss. Place them in polyethylene or waterproof paper bags, and seal the bags.
- Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at $0^{o}$ to $1.1^{o}$C.
- Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently. Stored fruits and vegetables release ethylene gas, which can cause woody plant buds to abort, making the scions useless.
- The scions should not be frozen during storage.




**Cross Section of a Woody Plant Stem**

In grafting, as well as budding, the vascular cambium of the scion or bud must be aligned with the vascular cambium of rootstock. In woody plants the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for the actively growing plant. This vascular cambium initiates callus tissue at the graft and bud unions in addition to stimulating tissue growth on the basal end of many vegetative cuttings before they have rooted.

## 2.2.5 Micro-Propagation and Hardening of Plants

### (A) Micro-Propagation

Micro-propagation means propagation of plants from very small plant parts called as explants (piece of plant may be cell, tissue, or even organ), tissue grown aseptically in the test tube or container under controlled nutritional and environmental conditions.

In vitro plantlets, which are free of pathogens, are used as initial material in such propagation programs. The methods used in these micro propagation programs mainly depend on their production volume and the available infrastructure. The basic micro propagation methods are described as follows.

1. **Micro-Propagation by Nodes:** This method is based on the principle that the node of an in vitro plantlet placed in an appropriate culture medium will induce the development of the axillary bud, resulting in a new in vitro plantlet. This type of propagation promotes the development of a pre-existing morphological structure. The nutritional and hormonal condition of the medium breaks the dormancy of the axillary bud and promotes its rapid development. Under controlled conditions micro propagation is fast. Each node planted in propagation medium will produce a plantlet which will occupy the full length of the test tube, after approximately four weeks for potato, and six weeks for sweet potato. The resultant in vitro plantlets may be transplanted to in vitro conditions in small pots in the greenhouse.
2. **Micro-propagation by Node Cuttings in a Liquid Medium**

This technique is applied both with potato and sweet potato to produce a large number of nodes rapidly. Stem cuttings with 5 to 8 nodes are prepared by removing both the apex and the root of the in vitro plant to be propagated. The stems are placed in the corresponding propagation liquid medium. It is also possible to use isolated nodes: the nodes will sprout and new plantlets will develop over a period of 3 to 4 weeks.

**3. Procedure of Micro Propagation**

1. Sterilize Petri dishes and prepare the laminar flow chamber by disinfecting the internal surfaces with alcohol. Sterilize the tools with an instrument sterilizer and place them on a sterile dish.
2. Open the tube, take off the plantlet and place it on a Petri dish with the help of forceps.
3. Remove the leaves and cut the nodes.
4. Open a tube containing fresh sterile medium and place a node inside, trying to plunge it slightly into the medium with the bud up. Close the tube.
5. Seal the tube with a gas-permeable plastic tape and label it correctly.
   It is recommended to place two explants in 16 x 125 mm tubes, three in 18 x 150 mm tubes, five in 25 x 150 mm tubes, and 20-30 in magenta vessels.

**Common Problems in Micro Propagation**

Some problems may appear in tissue culture according to the crop or variety. To solve them, it is necessary to apply one or several preventing methods such as:

**Phenolization:** The explants frequently become brown or blackish shortly after isolation. When this occurs, growth is inhibited and the tissue generally dies. The young tissues are less susceptible to darkening than the mature ones.

**Prevention:** The tissue darkening of the recently isolated explants and that of the medium may be generally prevented by:

(a) Removing the phenolic compounds produced by dispersion: Absorption by means of activated carbon and absorption by polyvinylpyrolidone (PVP).

(b) Modifying the redox potential. Reducing agents: ascorbic acid, citric acid, L-cisteine HCL, ditriotreitol, glutation and mercaptoethanol. Less availability of oxygen: stationary liquid media, inactivating the phenolase enzymes.

(c) Chelating agents: NaFeEDTA, EDTA, diethyldithiocarbamate, dimethyl-dithiocarbamate

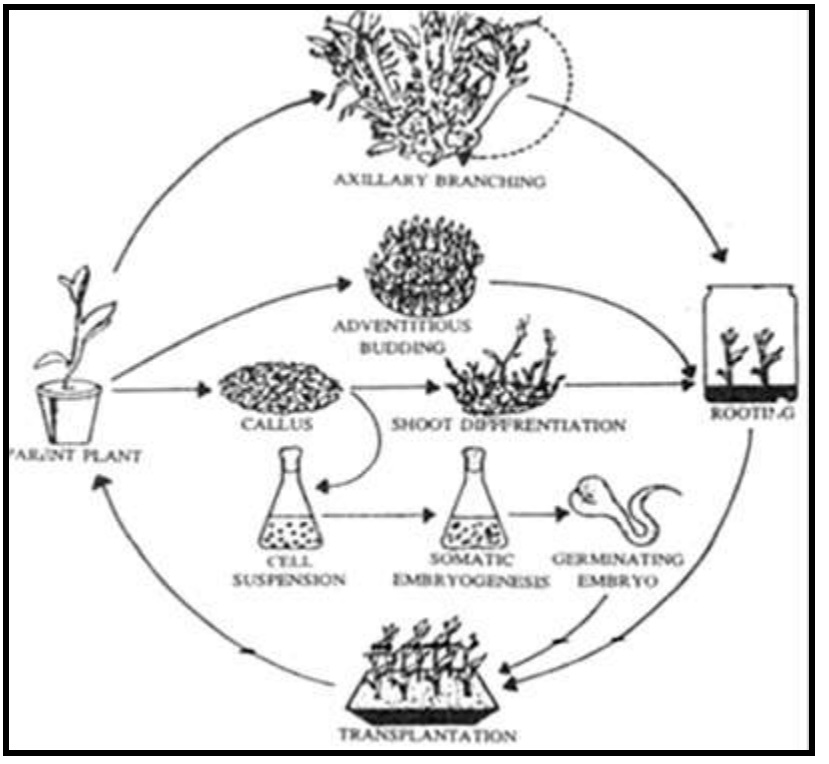
(d) Reducing the phenolasic activity and the availability of substrate with low pH and darkness

**4. Absence of Rooting**

The explants can naturally form roots during propagation. However, some wild potato species may show root production deficiency. Rooting may be induced by incorporating auxins, such as IAA, NAA, and IBA, or activated carbon to the culture medium. Scion is used rather than an entire scion containing many buds. Most budding is done just before or during the growing season. However some species may be budded during the winter while they are dormant.

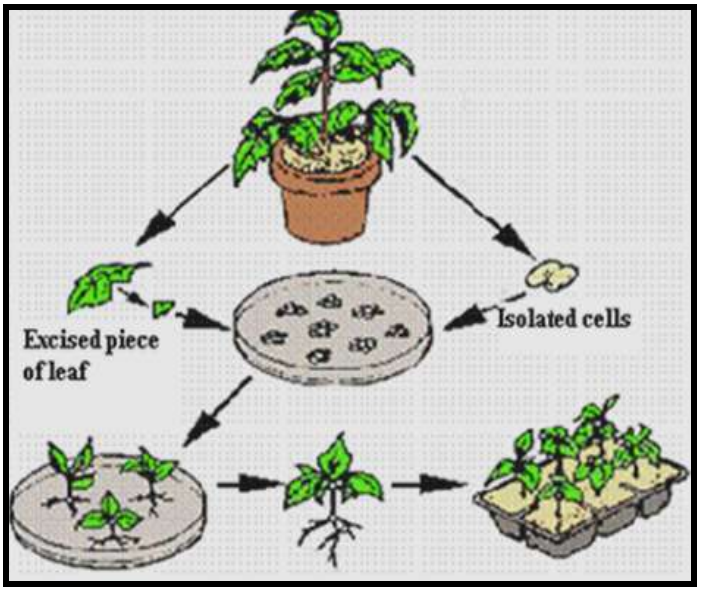
## A. Hardening of Plants

Hardening off plants is the process, usually undertaken after appropriate initial growth but before transplanting into the field. The process of hardening plants involves a transitional period in which plants are left outside during daylight hours only and in an area where they can be shaded and protected from wind. Watering is reduced as well during the hardening period. Gradually, the plant is allowed exposure to an increasing amount of sunlight and allowed to stay out later.




**Cycles of Micro Propagation**

Young, pampered seedlings that were grown either indoors or in a greenhouse will need a period to adjust and acclimate to outdoor conditions, prior to planting in the field. This transition period is called "hardening off". Hardening off gradually exposes the tender plants to wind, sun and rain and toughens them up by thickening the cuticle on the leaves so that the leaves lose less water. This helps to prevent transplant shock; seedlings that languish become stunted or die from sudden changes in temperature. Hardening off times depends on the type of plants you are growing and the temperature and temperature fluctuations.




**Micro Propagation by using Ex-Plants**

There are 3 Approaches to Hardening the Plants:

1. Gradual Longer periods of Time Outdoors
2. Place in a Cold Frame
3. Withholding Water

**1. Gradual Longer periods of Time Outdoors**

a) Begin 7 - 10 days before your transplanting date.
b) Place plants in a sheltered, shady spot outdoors. Leave them for 3-4 hours and gradually increase the time spent outside by 1-2 hours per day.
c) Bring plants back indoors each night.
d) After 2-3 days, move the plants into morning sun and return them to the shade in the noon.
e) After 7 days, the plants should be able to stand and bear sun for the entire day and stay out at night, if temperatures stay around $10^{o}$ C. Keep an eye out that the soil doesn't dry and bake the plants, if the weather is warm.
f) After 7 -10 days your plants are ready to transplant. Try to do so on a cloudy day and be sure to water well after planting.

**2. Placing in a Cold Frame**

a) Begin 7 - 10 days before your transplant date.
b) Indoor grown plants can be moved and left in a cold frame, for hardening off.
c) Turn off heating cables and/or open the cold frame cover for gradually longer periods of time. Start with 3-4 hours and gradually increase the exposure time by 1-2 hours per day.
d) Close the cover and resume heating at night, if temperatures drop below about 4.4 $^{0}$C.
e) Plants should be ready to transplant in 7 - 10 days. Try to do so on a cloudy day and be sure to water well after planting.

### 3. Withholding Water

Allowing seedlings to temporary wilting has the same effect as gradually exposing them to the elements.

a) Starting about 2 weeks before your transplant date, don't water your seedlings until they begin to show signs of temporary wilting.
b) At this point, water normally, and again wait for them to show symptoms of temporary wilting again.
c) After 2 weeks of this process, seedlings should be ready to transplant. Try to do so on a cloudy day and be sure to water well after planting.

### Instructions for Hardening the Grafted Plants

Hardening off plants is the act of acclimating plants that have been started indoors, to the harsher conditions of the outdoors. Hardening off plants is very simple, and will help to ensure success in growing plant outdoors.

To harden off plants, start by placing seedlings outdoors for 2-3 hours at a time during the day. The plants should be placed in an area that is shaded and protected from wind and any animals or pests. You should continue to do this for 3-4 days.

After 3-4 days, start leaving your plants out for longer periods of time, always making sure to bring them in each night. You should continue to do this for another 7-10 days, gradually increasing the time they are left out every few days.

For plants that will require full sun when planted in the ground, start slowly moving the plants out into the sunlight after the first 7 days or so. Plants should not be left in the sunlight for the whole day; rather they should have limited exposure for only a few hours. It is essential to make certain that the soil remains moist during this time.

After about two weeks of this process, the plants should be ready to be safely transplanted into the ground.

### Hardening of the Tissue Cultured Transplants

The term "hardening" refers to any treatment those results in a firming or hardening of plant tissue. Such a treatment reduces the growth rate, thickens the cuticle and waxy layers, reduces the percentage of freezable water in the plant and often results in a pink color in stems, leaf veins and petioles. Such plants often have smaller and darker green leaves than non hardened plants. Hardening results in an increased level of carbohydrates in the plant permitting a more rapid root development than occurs in non hardened plants. Cool-season flower and vegetable plants can develop hardiness allowing them to withstand cold temperatures.

### Cautions for Hardening Transplants

Hardening is not necessary for all transplants. The exception of tomatoes, plants that are susceptible to frost should not be hardened. Overly hardened plants while withstanding unfavorable outside conditions are slow to get started and may never overcome the stress placed on the plant during the hardening process. Plants are hardened for no longer than seven to ten days before planting to the garden site.


**Hardening of Chilli Plants**

**Hardening of Tomato Seedlings**

**Hardening of Ornamental Plants Under Poly House**

## 2.3 Glossary

**Apomixis:** Seedlings which are true to its mother plant.

**Asexual propagation:** Propagation by using vegetative parts of plants such as leaves, stems, and roots.

**Micro-propagation:** Technique of vegetative propagation by using tissue culture under aseptic conditions with artificial media.

**Parthinocarpy:** Formation of fruits without union of male and female organs.

**Polyembryonic varieties:** Varieties which give rise to more than one seedling from one seed.

**Seed dormancy:** Prevention of a seed from germination even when provided with favorable environment.

**Seed Germination:** Emersion of embryo from seed.

**Seed scarification:** Breaking, scratching, or softening the seed coat for easy germination.

**Seed Stratification:** Seeds of some temperate zone plants which are treated with chilling temperature.

**Sexual propagation:** Union of the pollen (male organs) with the egg (female organs) to produce a seed.

## 2.4 Points to Remember

- Both sexual and asexual methods are used in plant propagation. Selection of particular method for a particular crop is very essential. For production of hybrids in sexual plant propagation some selective treatments are necessary.
- To maintain the purity in seed produciton, rouging is essential. The structure of the seed is more complicated than any other vegetative part of the plant.
- The germination process in seed propagation and rooting process in vegetative propagation are the first steps in plant propagation.
- Tissue culture on commercial basis is important method in plant propagation but requires special techniques and skilled manpower.
- Seed play a very important role in crop production and varietal developement as it is the only means of sexual propagation.

## 2.5 Self Check Questions

1. Define: a. Seed Dormancy, b. Seed Viability, c. Sexual Propagation, d. Polyembryony, e. Seed Scarification
2. State the importance of asexual method of plant propagation.
3. What are the criteria for selection of good seeds?
4. What is seed treatment? State importance of seed treatment.

## 2.6 Do it Yourself

1. Enlist the crops grown in your area and classify them according to their method of propagation.
2. Visit a tissue culture laboratory and nursery in your area and observe the process of plant production and hardening.
3. Practice air layering in pomegranate, ground layering in guava, T budding in roses, patch budding in ber, top grafting in mango under the supervision of your resource person.

# Unit 3: Plant Nutrition and Management in Nursery

***Index***



## 3.1 Introduction

Plants, like animals and human being, require food for their liveliness, growth and development. This food is composed of certain elements and compounds often referred to as plant nutrients. The essential nutrients are the key components of the soil fertility. The chemical compounds required by the organism are termed as nutrients and their supply and absorption for growth is defined as nutrition. Plant nutrients are available in the form of organic and inorganic substances. Plants require 16 essential elements for their normal growth and completion of life cycle. On the basis of their relative concentration in plant tissues these are divided in to macro-nutrients and micro-nutrients. There are different types of manures and fertilizers available in the market for the supply of these nutrients. These fertilizers are provided to the plants by different fertilizer application techniques. Complete nutrition at nursery growth stage is very essential to avoid unhealthiness and deficiency. Proper nutrition gives healthy growth and resistance against pests, diseases and abiotic stresses in the environment. In the nursery, nutrient requirement is very low but it should be provided at the correct time. Advance fertilizer application technique enhances the nutrient absorption efficiency.

Integrated Nutrient Management (INM) is new attitude to supply nutrient to crop. Integrated Plant Nutrient System (IPNS) is the maintenance of soil fertility at an optimum level for sustainable productivity through optimization of benefits from all possible sources in an integrated manner. Integration of organic and inorganic fertilizers and manures give better results than the use of only organic or only inorganic fertilizers and manures. INM gives healthy and well developed plants in nursery. It also reduces the cost of production of nursery plants.

There are several media and media mixtures available for use in nursery. Media for plant growth and seed germination has great significance in nursery business. The

material for media can be used alone or as a combination of one or more products. Qualities of an ideal rooting and growing medium, commonly used media are briefly illustrated in the chapter. Water management in the nursery is also an important component. Quality of irrigation water plays an important role in production of healthy plants. Suitability of irrigation water depends upon water quality, soil, media, plant type, irrigation method, drainage and climate. We can achieve maximum water use efficiency by adopting advance irrigation technologies.

**At the end of this unit, you will be able to know and understand:**

- The various macro-nurients and micro-nutrients required by the plants.
- Role of various nutrients in the plant metabolism.
- The effects of nutrient deficiencies on plant growth.
- The sources of various plant nutrients and Integrated Nutrient Management.
- Process of potting, repotting and mulching in nursery.
- Application of plant growth regulators in nursery plants.
- Packing, transport and customer services in nursery plants.

## 3.2 Contents

### 3.2.1. Plant Nutrients and their Requirement

**Plant Nutrition**

Plants require food for their growth and development. The plant food is composed of certain elements which are often referred to as plant nutrients or plant food elements. Plants absorb a large number of elements from soil, air and water during growth and development. But only sixteen elements are found to be essential in plant nutrition. The criteria to judge essentiality of an element to plants have been worked out. They are as under:

1. Deficiency of the nutrient makes it difficult for the plant to complete the vegetative or reproductive stage of its growth.
2. The deficiency is specific to the nutrient in question and as such can be prevented or corrected only by supplying that particular element to the plant.
3. The nutrient must have direct influence on the plant. It must be directly involved in the metabolism of the plant.

**Essential plant Nutrients and their Sources:**

| ***Source*** | ***Plant Nutrients*** | ***Class of Nutrient*** |
|---|---|---|
| Air | Carbon (C) | Macronutrients |
| Water | Oxygen ($O_2$) | Macronutrients |
| | Hydrogen ($H_2$) | Macronutrients |
| Soil | Nitrogen (N) | Macronutrients |
| | Phosphorous (P) | Macronutrients |
| | Potassium (K) | Macronutrients |

| *Source* | *Plant Nutrients* | *Class of Nutrient* |
|---|---|---|
| | Magnesium (Mg) | Macronutrients |
| | Calcium (Ca) | Macronutrients |
| | Sulphur (S) | Macronutrients |
| | Iron (Fe) | Micronutrients |
| | Manganese (Mn) | Micronutrients |
| | Boron (B) | Micronutrients |
| | Zinc (Zn) | Micronutrients |
| | Copper (Cu) | Micronutrients |
| | Molybdenum (Mo) | Micronutrients |
| | Chlorine (Cl) | Micronutrients |
| | Nickel (Ni) | Beneficial elements |
| | Cobalt (Co) | Beneficial elements |
| | Sodium (Na) | Beneficial elements |
| | Vanadium (V) | Beneficial elements |

Nitrogen, Phosphorous and Potassium are called as Primary nutrients, while Calcium, Magnesium and Sulphur are called secondary Nutrients.

**Macronutrients**

Out of the 16 essential plant nutrients six elements are used by plants in large quantities. These are N, P, K, Ca, Mg and S. Since these elements are used in relatively large amount they are designated as "Macronutrients". The first three nutrients namely NPK are utilized by plants in considerable quantities. Majority of soils of the world are consequently found deficient in these nutrients, hence N, P, and K are often called as Primary Nutrients. Ca, Mg and S are called secondary nutrients due to their secondary importance to the manufacturers of NPK fertilizers.

**Micronutrients**

The other seven nutrients namely Fe, Mn, B, Zn, Ca, Mo, Cl and Ni are used by field crops in very small quantity hence these are called Micronutrients. These nutrients are also called Trace, Minor or Rare elements. They are however essential to plant growth.

The nutrients should fulfill the conditions for proper growth and development of plants.

They must be present in the soil in available form. The nutrient must be present in optimum concentration for plant growth. Deficiency or excess of any nutrient limits plant growth. There must be a proper balance among the concentrations of the various soluble nutrients in the soil solution.

**Nutrient Deficiency Symptoms in Plants**

The plants suffering from severe deficiencies or toxicities of mineral nutrients usually develop well defined and typical signs of disorders in various organs particularly in leaves and which can be easily detected by the eyes. Usually specific abnormal colors

are developed in the leaves due to deficiency of plant nutrients. So this requires experience and practice in the field to recognize particular nutrient deficiency.

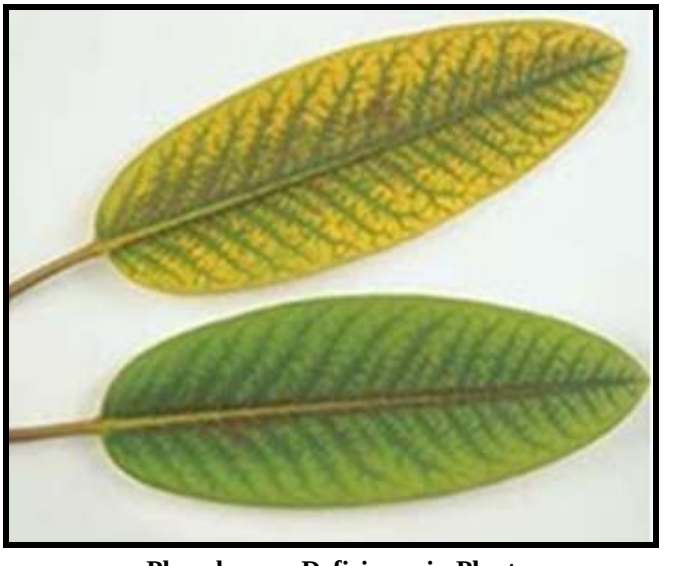
Plant Nutrient showing deficiency on older or lower leaves:
Nitrogen, Phosphorous, Magnesium, Potassium and Zinc
Plant Nutrient showing deficiencies on younger leaves or bud leaves are:
Calcium, Boron, Copper, Manganese, Sulphur and Iron

**Typical Deficiency Symptoms**

1. **Nitrogen (N):** Yellow or pale green color of leaves. Drying of bottom leaves and short plant height.

**Healthy Leaf at Left side and Nitrogen Deficiency leaf at Right side**

2. **Phosphorous (P):** Leaves developing red and purple color. Slow growth and late maturity is observed. Lower leaves dry and develop purple colours between veins. Leaf petioles also develop purple color.



**Phosphorous Deficiency in Plant**

3. **Potassium (K):** Bottom leaves are scorched or burned on margins and tips. Leaves thicken and curl. Deficiency first develops in the wet portion of field.

**Potassium Deficiency in Plants**

4. **Calcium (Ca):** Yong leaves of the terminal buds develop wrinkled appearance and dieback at the tips and margins. Stalk finally dies at the terminal bud.

**Calcium Deficiency in plant**

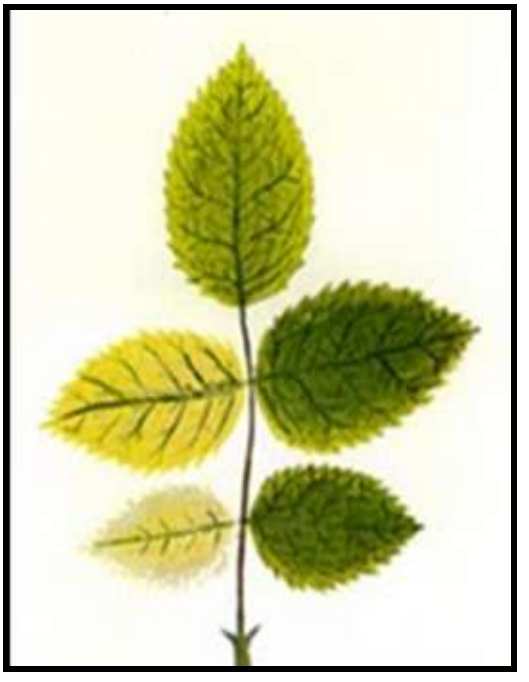
5. **Magnesium (Mg):** There is general loss of green color starting with the bottom leaves and moving upward. Veins of the leaves remain green. In cotton the lower leaves turn purplish red with green veins.


**Magnesium Deficiency in plant**

6. **Sulphur (S)**: The veins and the tissue between them become light green in colour in young leaves. The growth of the plant is slow.

**Sulphur Deficiency in Gerbera**

7. **Iron (Fe):** Young leaves turn chlorotic. The main veins remain green. The stalk is short and slender. There is dieback of young growing tissues.



**Iron Deficiency in Rose**


**Iron Deficiency in Gerbera**

8. **Manganese (Mn):** Spots of dead tissue scattered over young leaves. The smallest veins tend to remain green.

**Manganese Deficiency in plant**

9. **Zinc (Zn**): There is yellow stripping of the leaves between the veins. Older leaves die, and plant is severally dwarfed.

**Zinc Deficiency**

10. **Boron (B):** Yong leaves of the terminal bud becoming light green at the base, with final breakdown. In later growth, leaves become twisted; stalk finally dies at terminal bud. Browning of curd and lesions in pith in cauliflower.


**Boron Deficiency in Gerbera**

11. **Copper (Cu):** Yong leaves permanently wilted without spotting or marked chlorosis. Yellowing and chlorosis of normally green leaves. White tip or yellow tip diseases is observed in grains with dwarfed or distorted heads.
12. **Molybdenum (Mb):** Lower leaves of tomato showing mottling, necrosis and curling of leaf edges. In oats, leaves bend backward, later break at affected areas with necrosis.
13. **Chlorine (Cl):** Leaves display the symptom of wilting of leaf blade tips. Chlorosis, bronzing and necrosis are also observed in areas proximal to wilting.
14. **Nickel (Ni):** Visual deficiency symptoms of nickel have not yet been found adequately. Its deficiency causes accumulation of nitrates and decrease in amino acid content in barley containing less than 0.1mg Ni/Kg.

**Role and Functions of Essential Nutrients**

1. **Nitrogen**
   i. Nitrogen is an essential constituent of proteins and chlorophyll and is present in many other compounds in plant metabolism, such as nucleotides phosphatides, alkaloids, enzymes, hormones, vitamins etc. It is thus a very basic constituent of plant life.
   ii. Imparts dark green colour to plants. It promotes vegetative growth in leaves, stem and produces rapid early growth.
   iii. It improves the succulence of leafy vegetables and fodder crops and increases the protein content in it.
   iv. Governs considerably the utilization of phosphorous, potassium and other elements
2. **Phosphorous**
   i. Phosphorous is a constituent of nucleic acid, phytin and phospholipids. An adequate supply of Phosphorous early in plant life is important for the development of the reproductive parts of the plant
   ii. Phosphorous is also an essential constituent of majority of enzymes which are of great importance in the transformation of energy, in carbohydrate metabolism, fat metabolism and also in respiration (catabolism of carbohydrates) in plants. It is closely related to cell division and development.
   iii. Stimulates early root development and growth, their by helping to establish seedling quickly.
   iv. Brings about early maturity of crops particularly cereals and counter acts the effects of excessive nitrogen.
   v. Stimulates flowering, aids in seed formation, increases grain to stalk ratio. It also improves the quality of food grains and other crops.
   vi. When applied to legumes it enhances the activity of Rhizobium and increases the formation of root nodules. Thus it helps in fixing more atmospheric nitrogen in root nodules. With Phosphorous deficiency, legumes plants may simultaneously suffer from nitrogen as well as potassium deficiency.

vii. Excess of Phosphorous in soil may cause deficiencies of some nutrients particularly iron and zinc. It may also reduce the detrimental effects of over liming.

**3. Potassium**

Unlike all major nutrients potassium does not enter in to the composition of any of the important plant constituent, such as proteins, chlorophyll, fats and carbohydrates concerned in plant metabolism. It occurs in as state of solution in the cell sap. Being soluble it can be removed with solution in water from the plant tissue.

i. Imparts increased vigor and disease resistance to plants and produce strong, stiff straw in cereals, specially paddy and wheat. It also imparts winter hardiness to legumes and other crops.
ii. It regulates water conditions within the plant cell and water loss from the plant by maintaining the balance between anabolism, respiration and transpiration. It reduces tendency to wilt and helps in better utilizations of available water.
iii. Essential in the formation and transfer of starches and sugar. Thus potassium is required in large quantities for potato, sweet potato, turnip, Banana, suran and Tapioca.
iv. Helps in formation of proteins and chlorophyll, it increases plumpness of grains and seeds and acts as an accelerator of enzyme action.
v. Counteracts the injurious effects of excess nitrogen in plants. Hence, a balanced ratio of N and K is important in plant nutrition.
vi. Improves the quality of final products such as improvement in quality of tobacco leaf, quality of fiber in fiber crops, taste size and keeping quality of fruits. With citrus fruits however, an excess of potash has a bad effect on quality.

**4. Calcium**

i. It is a constituent of cell wall; as such it increases stiffness of straw and promotes early root development and growth.
ii. Provides a base for neutralization of organic acids, commonly termed as poisons produced in the plant.
iii. Essential to activate growing points, especially root tips. At the same time it does not move freely from the older to the younger parts of plant. This is the main reason why calcium deficiency symptoms are first manifested at the tips of shoots and roots.
iv. Improves intake of other plant nutrients, especially nitrogen and trace elements such as iron, Boron, zinc, copper and manganese by correcting soil pH and encourages seed production.

**5. Magnesium**

i. Since it is constituent of chlorophyll, it is essential for all green plants. It helps in maintaining the dark green colour of leaves.
ii. Plays a role in the production of carbohydrates, proteins, fats and vitamins and in certain catalytic reactions in the enzyme systems.

iii. Acts as carrier of phosphorous in plants particularly in connection with the formation of seeds of high oil content. Thus it promotes the formation of oils and fats.
iv. Helps the translocation of starches and regulates the uptake of other nutrients in plants.

**6. Sulphur**

i. Though sulphur is not constituent of chlorophyll, it helps in chlorophyll formation and encourages vegetative plant growth.
ii. It is an essential constituent of many proteins, enzymes and certain volatile compounds such as mustard oil and helps in the oxidation-reduction system in respiration of plants.
iii. Increases root growth, stimulates seed formation and promotes nodule formation on roots of legumes.

**7. Boron**

i. The primary role of boron appears to be concerned with calcium metabolism both with its uptake by roots and its efficient use in plants.
ii. Tends to keep calcium soluble and increases its mobility in the plant, helps in absorption in of nitrogen.
iii. Is a constituent of cell membrane and is essential for cell division and is necessary for translocation of sugars in plants.
iv. Helps the vascular system in roots to give out branches (rootlets) to supply nodule bacteria with carbohydrate so that bacteria may not become parasitic.
v. Boron has effect on many other functions in plant such as active salt absorption, hormone movement, flowering and fruiting processes, pollen germination, carbohydrates as well as nitrogen metabolism, metabolism of peptic substances.

**8. Manganese**

i. The function of manganese is regarded as being closely associated with that of iron. It also supports the movement of iron in the plant and helps chlorophyll formation in plants.
ii. Acts as catalyst in oxidation and reduction reactions within the plant tissues. Thus as a constituents of enzymes it helps in respiration and in protein synthesis in the chloroplasts.
iii. A good manganese supply some times helps in counteracting the bad effect of poor aeration in soil.

**9. Iron**

i. It helps in chlorophyll formation. A deficiency of iron causes chlorosis between the veins of leaves. Iron is very immobile element within the plant. Iron deficiency is noticeable in younger leaves at the growing region. It also helps in absorption of other nutrients.

ii. As constituent of enzyme systems which bring about oxidation reduction reaction in the plant, it regulates respiration, photosynthesis, reduction of nitrates and sulphates and is essential for the synthesis of proteins contained in the chloroplasts.

**10. Zinc**

i. Zinc is a constituent of several enzyme systems which regulate various metabolic reactions in the plant. E.g. formation of chlorophyll in plants.
ii. It influences the formation of some growth hormones in the plant and is associated with water uptake and water relations in the plant.

**11. Molybdenum**

i. Acts in enzyme system which brings about oxidation reduction reactions, especially the reduction of nitrates to ammonia prior to amino acid and protein synthesis in the cells of the plant.
ii. Is essential for the process of atmospheric nitrogen fixation, both symbiotic and non symbiotic. It increases efficiency of legumes in fixing atmospheric nitrogen.

**12. Copper**

i. Copper forms many compounds with amino acids and proteins in the plant.
ii. It acts as electron carrier in enzymes which bring about oxidation reduction reaction in plants. It also helps in utilization of iron in chlorophyll synthesis.

**13. Chlorine**

The need for chlorine for proper plant growth and development has been established for sugar beet, carrot, lettuce. However, the exact role which chlorine plays in plant nutrition has not yet been clearly defined.

**14. Nickel**

It is essential for hydrogenase, methyl reductase, and ureas activities that regulate Nitrogen metabolism. It is needed for grain filling and seed vitality.

**Fertilizers Supplying Various Plant Nutrients**

**1. Nitrogenous Fertilizers:**

| ***Sr. No.*** | ***Name of fertilizer*** | ***N %*** |
|---|---|---|
| 1. | Ammonium sulphate | 20.6 |
| 2. | Urea | 46 |
| 3. | Urea coated | 45 |
| 4. | Calcium ammonium nitrate | 25 |
| 5. | Urea ammonium nitrate | 32 |

**2. Phosphatic Fertilizers:**

| *Sr. No.* | *Name of fertilizer* | *$P_2O_5$ %* |
|---|---|---|
| 1 | Single Super Phosphate | 16 ($P_2O_5$ powdered) |
| 2 | Triple Super Phosphate | 48 |
| 3 | Bone Meal Raw | 20 |
| 4 | Bone Meal Steamed | 16 |
| 5 | Single Super Phosphate | 16 ($P_2O_5$ granulated) |

**3. Potassic Fertilizers**

| *Sr. No.* | *Name of fertilizer* | *$K_2O$ %* |
|---|---|---|
| 1 | Potassium chloride (MOP) | 60 (Powder) |
| 2 | Potassium sulphate | 50 |
| 3 | Potassium chloride (MOP) | 60 (Granular) |

**Nitrogen and Phosphorous Complex Fertilizers**

1. Diammonium phosphate: 18 % N: 46 % $P_2O_5$
2. Ammonium Phosphate Sulphate: 20 % N: 20 % $P_2O_5$
3. Ammonium Phosphate Sulphate Nitrate: 20 % N: 20 % $P_2O_5$ : 13 % S
4. Ammonium Phosphate Sulphate: 18 % N: 9 % $P_2O_5$
5. Nitro Phosphate: 20 % N: 20 % $P_2O_5$
6. Urea Ammonium Phosphate: 28 % N: 28 % $P_2O_5$
7. Urea Ammonium Phosphate: 24 % N: 24 % $P_2O_5$
8. Urea Ammonium Phosphate: 20 % N: 20 % $P_2O_5$

**Nitrogen, Phosphorous and Potassium Complex Fertilizers**

1. N:P:K (15:15:15)
2. N:P:K (10:26:26)
3. N:P:K (12:32:16)
4. N:P:K (22:22:11)
5. N:P:K (14:35:14)
6. N:P:K (17:17:17)
7. N:P:K (14:28:14)
8. N:P:K (19:19:19)
9. N:P:K (20:10:10)

**Micro Nutrients**

1. Zinc sulphate Heptahydrates ($ZnSO_4$, $7H_2O$): Zn - 21%
2. Manganese sulphate (MnSO4): Mn- 30.5%
3. Borax (Sodium tetra borate) ($Na_2B_4O_7$, 10 $H_2O$) – for soil: B- 10.5 %
4. Copper sulphate ($CuSO_4$, $5H_2O$): Cu- 24 %
5. Ferrous sulphate ($FeSO_4$, $7H_2O$): Fe- 19 %
6. Ammonium molybdate ($NH_4$): Mo- 52 %
7. Chelated zinc Zn- EDTA: Zn- 12 %

| | |
|---|---|
| 8. Chelated Fe- EDTA: | Fe- 12 % |
| 9. Zinc sulphate monohydrate ($ZnSO_4.H_2O$): | Zn – 33 % |
| 10. Manganese Sulphate: | Mn 9.6 % |
| 11. Boric acid ($H_3BO_3$): | B – 17 % |

**Fortified Fertilizers**

| | |
|---|---|
| 1. Boronated Single Super Phosphate: | 16% $P_2O_5$, 0.18% B |
| 2. Zinc Coated Urea: | N - 43%, Zn - 2% |

## 3.2.2 Manures and Fertilizers Application in Nursery

**Types of Manures**

The excreta of animals including dung and urine, along with straw and other organic materials are used as manures in crop production. The decomposed manure is called Farm Yard Manure. The average composition of well decomposed Farm Yard Manure is 0.5 per cent nitrogen (N), 0.3 per cent Phosphorous (P2O5) and 0.5 per cent Potassium ($K_2O$). For the best performance of fruits and vegetables balanced nutrition of the nursery plants are necessary. Balance nutrition can be achieved by supplying nutrients in both organic and inorganic form.

- Organic manures
- Inorganic fertilizers or chemical fertilizers
- Biofertilizers

**Manures**

Manures are prepared by using plants and animal's debris.

It can be categorized as follows:

1. Manures from plant origin e.g. green manures
2. Manures from animal origin e.g. Poultry manure
3. Manures from plants and animal origin e.g. Compost, Farm Yard Manure.
4. Organic fertilizers e.g. Bone Meal, Fish Meal, Blood Meal.

**Biofertilizers**

1. Nitrogen supplying biofertilizers- Azotobacter, Rhyzobium, Acetobacter, Azospyrillum.
2. Phosphate supplying biofertilizers – Phosphate solubalizing bacterias (PSB)
3. Microbial decomposers- Tricoderma viridae

**Important Points regarding the Nutrition Management in Nursery Plants**

- Selective and balanced nutrition should be given to the mother plants through soil or irrigation. Excess nitrogen will reduce the root growth.
- In nursery different types of rooting media are used. It doesn't contain nutrients so we have to provide nutrition according to plants need.

- In nursery extra attention should be given to nutrition in sprouting, root initiation stage, hardening of plants. Nutrient deficiency can be reclaimed through application of foliar sprays.
- For balanced nutrition organic manures, inorganic fertilizers and biofertilizers should be used together.

**Fertilizer Requirement of Different Nursery Plants.**

Manures and Fertilizers are applied in a Nursery to provide adequate nutrients for growth and development of nursery plants, to provide essential nutrients during critical growth period of plants to achieve well developed, healthy and pest and disease free plant growth.

**(A) Fertilizer Requirement of Vegetable Nursery Plants**

1. Fully decomposed organic manure and chemical fertilizer grade is used to fortify sterilized coco peat.
2. Drenching: Soluble fertilizers as 19:19:19, 12:61:00, 00:52:34, 00:00:50, 13:00:45 are used at 2gm/lit of water along with fungicides. In vegetable nursery tomato, chilly, brinjal, cabbage, cauliflower, melons at the interval of 6-7 days for the period of 25-30 days 3-4 times till the date of transplanting.
3. Foliar application: The same grades of soluble fertilizers are used in the foliar application @ 2 gm/ liter of water. The foliar application is done 4-5 times according to the growth stage of nursery plants until the seedlings are ready for transplanting.

**(B) Fertilizer Requirement of Fruit Nursery Plants.**

1. Media for filling polythene bags – Red soil and decomposed FYM or compost are mixed thoroughly.
2. Drenching of soluble fertilizers is done 5-6 times according to growth stages @ 2gm/liter of water.
3. Foliar application of fertilizers 5-6 times through spraying is done according to plant growth stage @ 2gm/liter of water.

**Methods of Application of Manures and Fertilizers**

1. **Broadcasting:**
   Bulky organic manure like FYM and compost are broadcasted over the beds and mixed thoroughly with the help of a spade or rake. The seeds are sown once the beds are well prepared.
2. **Ring Around Stem:**
   Grown up trees and plants are given manures and fertilizers by making ring around the trunk or stem of the plant.
3. **Fertilizer Placing Near Plants in Polybags/Urea Brickets**
   Fertilizers are placed directly in the polybags near the stem with the help of weeding hoe in adequate doses.

4. **Fertigation:**
   Adequate dose of fertilizers can be mixed in the irrigation water and given to nursery plants through drip or sprinkler irrigation or drenching near the stem.
5. **Foliar Fertilization:**
   Fertilization of plants or feeding nutrients to the plants by spraying chemical fertilizers on the foliage. This is also known as foliar feeding or spray fertilization.

## 3.2.3. Growth Media and Media Preparation in Nursery

Media for plant growth and seed germination has great significance in nursery business. The material for rooting and growing media may be used either alone or incorporated with one or more products in combination. The materials used for rooting media may be naturally occurring or may be manufactured artificially.

**Qualities of an Ideal Rooting Media:**

- The substance must have appropriate physical and chemical properties.
- They must retain sufficient water and air to allow sufficient drainage.
- The substance must be free from weed seeds, insect pest and diseases.
- The acidity and alkalinity of the medium should be in optimum for different species.
- The medium must be sufficiently firm and dense to hold the cuttings and seeds in place during rooting or germination.
- Its volume must be fairly constant when wet or dry and it must be capable of being sterilized.
- The rooting media should support the cuttings to avoid lodging. This is particularly important whenever larger sized cuttings are used under mist chamber conditions.

**Media for Propagation and Growing Nursery Plants**

There are several media and mixtures of different kind are available for use in propagation such as in seed germination, rooting of cuttings and for growing container stock. Commonly used media with a brief description of properties are given below.

1. **Soil:** Soil is the most important and widely used media in the world so also called as 'Universal Media'. A soil is composed of materials in the solid, liquid and gaseous states. This material must exist in the proper proportions for satisfactory plant growth. The texture of soil depends upon relative proportions of sand, silt and clay. Maintenance of soil structure in favorable and granular form is very important.
2. **Sand:** Sand consists of small rock grains (0.05-2.0mm in diameter) formed as result of the weathering of various rocks. Its mineral composition depends upon type of rock. Quartz sand is generally used for propagation and plastering grade sand is used for rooting of cuttings. Sand should be preferably sterilized before use.
3. **Peat:** There are different types of peats available. Peat consists of the remains of aquatic marsh or swamp vegetation, which has been preserved under water in a partially decomposed state. Composition of peat varies widely depending upon the type of vegetation, decomposition and degree of acidity. It is a uniform product, free

from pests, diseases and weed seeds, useful for growing rooted cuttings or seedlings. Peat is easily compressed and can be purchased in polythene bags. Peat is the material most commonly used with many other different propagation media. Peat can be mixed, with either fine or coarse sand, perlite or vermiculite, sawdust. Peat is formed by the partial decomposition of plants in areas of high rainfall and the types of peat can vary considerably in colour and structure. A medium grade sphagnum peat is generally recommended as a nursery media.

4. **Sphagnum Moss:** The Sphagnum moss is the dehydrated remains of acid bog plants of the genus *Sphagnum*. It is relatively sterile, light in weight and contains specific fungi static substances. It has a higher water holding capacity. It absorbs water 10-20 times of its own weight.

5. **Vermiculite:** It is micaceous mineral, which expands markedly when heated. It is chemically a hydrated magnesium-aluminium-iron silicate. It is very light in weight, neutral in reaction with good buffering properties and insoluble in water. Normally has pH range between 6.0-6.5. It is normally mixed with peat moss, because vermiculite alone will not support the cuttings. It is suitable for rooting the cuttings intended for export to overcome specific plant quarantine regulation.

6. **Perlite:** It is gray coloured material of volcanic origin mined from flows and has natural reaction with no buffering, cation exchange capacity and mineral content. Chemically perlite is made up of alumino-silicates. It is a light sterile material containing no nutrients. It has a pH of 6.0-7.5. It may be used alone but it is best used with peat moss for woody ornamentals. Since it is little chance of damage to the structures from weight stress.

7. **Pumice:** It is gray or white coloured volcanic rock, which was originally formed from the gases to give it a sponge like porous character. It is made up of aluminium silicate and also contains small quantities of potassium and sodium. It provides good aeration and drainage to medium.

8. **Leaf Mould:** Leaf mould can be prepared by placing leaves and soil in an alternate layers. For accelerating decomposition, small quantity of ammonium sulphates is added. Leaf mould becomes ready within 12-14 months. This material is rarely used in modern large scale propagation structures.

9. **Sawdust and Wood Shavings:** These are mostly used for propagation media. A byproduct formed during the processing of wood material. It is free from salts nitrogen deficiency, if sawdust is excessively composed of, there is problem of drainage. Controlled release fertilizers can be used along with sawdust.

10. **Coco Peat:** It is also called as coco dust. Byproduct of coconut processing for fiber production. It is most popular growing media available these days. It has excellent aeration of 15-25 per cent because of its fine structure. Coco-substrate is expected to degrade slower than other substrates such as peat moss. Potassium is not added in this medium as it is already available in coir. This medium requires addition of more

amount of nitrogen as microorganism in coco peat need to break down easily degradable substrates present in Coco peat.

11. **Polymers**: Since container-grown plants rely on regular watering to survive, some mixes contain polymers to hold moisture. Polymers, which may look like tiny plastic marbles, act like sponges. They absorb and hold water when the medium is moist, but release it back into the soil when dry. This helps maintain a consistent level of moisture for plant roots. Several different brands and forms of polymers are available at local nurseries.

**Media Preparation for Nursery:**

In a Nursery the propagated young seedlings or rooted cuttings are sometimes planted directly in the field but frequently they are planted in soil mixtures in some type of container such as peat or plastic pots or clay flower pots or metal cans.

Potting mixtures for rooted cuttings and young seedlings generally contains 1 part of sand, 1 part of Loam soil and 1 part of peat moss or shredded bark or leaf mould is generally recommended as potting mixture.

**Potting Mixtures and Potting Yard**

For better success of nursery plants a good potting mixture is necessary. The potting mixtures for different purpose can be prepared by mixing fertile soil, well decomposed FYM, leaf mould, oil cakes etc. in different proportions. The potting mixture may be kept near the potting yard, where potting and packaging is carried out.

Sand, Loamy soil, FYM in 1:2:1 proportion in generally used to grow vegetable seedling in rasied beds.

**Different Media Combinations for Vegetable Nursery are as follows:**

- Loamy soil + Sand + FYM + Vermicompost
- Loamy soil + Sand + FYM + Biofertilizers
- Loamy soil + Sand + Vermicompost + Biofertilizers
- Loamy soil + Sand + Vermicompost + Oil cakes + Biofertilizers
- Loamy soil + Sand + Compost + Biofertilizers
- Loamy soil + Sand + FYM + Oil cakes
- Loamy soil + Sand + FYM + Oil cakes + Biofertilizers
- Loamy soil + Sand + Leaf mould + Oil cakes

## 3.2.4. Water Quality and Water Management in Nursery

**Ideal Water Quality for Nursery**

All irrigation water contains varying amounts of soluble salts of calcium, sodium, magnesium and others. Excess amount of any component in water degrade the quality of water and develops toxicity. This can be affecting adversely on the nursery plants for further growth and development. The representative sample of water should be tested before use for nursery irrigation. The nutritional imbalance also observed because of excess pH of irrigation water.

It is necessary to have the basic information with regard to quality of irrigation water to assess its effect on soils and plants in nursery.

**Collection of Irrigation Water Sample**

The water sample is colleted about 500 ml glasses or polythene bottle which should be preferably be transparent. The container should be thoroughly cleaned before use and should be rinsed three to four times with the water from which the sample is to be drawn.

If the source of irrigation water is tank, canal or river the sample should be drawn either from a spot away from the sides or from the middle of the stream.

After running the pump for 30 min the tube well sample has to be collected. In case of open well, several buckets of water have to be thrown out first before sampling. The water sample after proper labeling and sealing must be sent to the laboratory immediately for testing to avoid any change or deterioration. If a few days delay is inevitable than two or three drops of pure toluene may be added to prevent bacterial activity.

**Water Quality Criteria for Irrigation**

The following chemical properties are normally tested while assessing the quality of water for irrigation.

- Total Soluble Salt concentration (TSS)
- Sodium Absorption Ratio (SAR)
- Residual Sodium Carbonate (RSC)
- Boron Content

1. **Total Soluble Salt (TSS):** The total soluble salt concentration is measured as electrical conductivity (EC) and expressed as ds/m at $25^0$C temperature.

| ***Sr. No.*** | ***Salt Concentration (TSS)*** | ***EC dsm$^{-1}$ at 25$^0$c*** | ***Class*** |
|---|---|---|---|
| 1 | Low | <1.5 | $C_1$ |
| 2 | Medium | 1.6-3.0 | $C_2$ |
| 3 | High | 3.1-6.0 | $C_3$ |
| 4 | Very high | 6.0 | $C_4$ |

2. **Sodium Absorption Ratio (SAR):** It is the ratio of Sodium ($Na^+$) to the square root of half of the combined concentration of Calcium ($Ca^{++}$) and Magnesium ($Mg^{2+}$). It is used to assess the alkali related hazard of the water.

$$SAR = \frac{N^{a+}}{\sqrt{\frac{Ca^2 + Mg^{2+}}{2}}}$$

Where the concentration of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ are expressed as me/lit

| ***Sr. No.*** | ***SAR Class*** | ***SAR Range*** | ***Classes*** |
|---|---|---|---|
| 1 | Low | <10 | S1 |
| 2 | Medium | 11-18 | S2 |

| | | | |
|---|---|---|---|
| 3 | High | 19-26 | S3 |
| 4 | Very high | >26 | S4 |

3. **Residual Sodium Carbonate (RSC):** It is the difference between the combined concentration of Bicarbonate ($HCO_3^{2-}$) and carbonate ($CO_3$) with that of calcium and Magnesium and expressed in terms of me/liter.

| ***Sr. No.*** | ***RSC Class*** | ***SAR range*** | ***Classes*** |
|---|---|---|---|
| 1 | Low | <1.5 | 1 |
| 2 | Medium | 1.6-3.0 | 2 |
| 3 | High | 3.1-6.0 | 3 |
| 4 | Very high | >6.0 | 4 |

4. **Boron:** Though boron is an essential plant nutrient it becomes toxic if present in water beyond a particular level.

| ***Sr. No.*** | ***Boron Value*** | ***Boron (ppm)*** |
|---|---|---|
| 1 | Low | <1.0 |
| 2 | Medium | 1.1-2.0 |
| 3 | High | 2.1-4.0 |
| 4 | Very high | >4.0 |

**Relative Salt Tolerance of a Crop**

1. Salt Tolerant (CP1) Crops: Barley, Sugar beat, Tobacco, Cotton, Wheat, Sugarcane, Date palm, Coconut.
2. Salt Semi tolerant(CP2) Crops: Oats, Rice, Jowar, Maize, Bajara, Wheat, Red gram Castor, Jute, Soybean, Tomato, Cabbage, Cauliflower, Potato, Radish, Carrot, Onion, Peas, Cucumber, Grapes, Fig, Guava, Mango, Banana, Pomegranate, Orange and Lemon.
3. Salt Sensitive (CP3) Crops: Green gram, Peach, Pear, Apple, Pineapple.

**Management of Poor Quality Water for Irrigation:**

1. Dilution with good quality irrigation water.
2. Flooding with good quality water once or twice to flush out salts beyond root zone.
3. Gypsum mixing with water to reduce Sodium salt hazards and also to improve soil structure.
4. Providing drainage to remove salts.
5. Using poor quality water in sandy soils.
6. Growing salt tolerant crops.
7. Adopting drip irrigation for poor quality water.

**Irrigation Systems in Vegetable and Nursery Crops**

The present techniques used by growers, both in the production of vegetables and in the nursery cultivations, are based on overhead and localized irrigation. The last one is able to give a higher efficiency than traditional irrigation systems like flood irrigation. Low efficiency of traditional irrigation systems is linked to the great quantity of water lost during irrigation, because the quality of water supplied is much larger than plant absorption and soil retention capacities. By localized irrigation these problems are minimized; the main handicap of this system is the high installation costs. However, the investment will be paid back by greater crop production and better qualities in the productions.

**Overhead Irrigation**

This system is frequently used in vegetable production. It has a lower efficiency than localized irrigation because of the greater volumes of water required, but the efficiency is greater than for surface irrigation (flow and border irrigation). Other positive aspects of this system are:

- Possibility of watering the ground without leveling;
- Decrease in soil erosion and less damage to the soil structure, by operating with an adapted water amount and drop size;
- Decrease in water run-off and fertilizers losses: in fact this system allows to use only about a half the water volumes of the gravity systems at the same effect for the crop. Normally, with overhead irrigation water consumption goes from about 500 cubic meters per hectare in clay soils with localized irrigation. It is about 1300 cubic meters per hectare with flowing irrigation.
- Possibility to influence temperatures, both to decrease damages from frost and stresses caused by heat.

**Micro-Irrigation**

Micro-irrigation is the system of irrigation which is one of the most effective system to reach the above listed goals. It localizes the water directly to the soil where the root systems are, thus wetting only a portion of the soil. The localization of the water in the root zone decreases the wastage of water and increase the water use efficiency.

Benefits of localized irrigation are:

- Reduction of costs for the preparation of the soil;
- Possibility of doing cultural operations such as harrowing between rows.
- Possibility to fertilize plants near their root zones promoting an easier absorption of nutrients.

Even if micro-irrigation is usually adopted for and is called “micro-irrigation”, when it is used to irrigate from below the ground level it is called the “sub-surface irrigation”. Both systems release water using drip emitters. The function of the drip emitters is to reduce the pressure inside the pipes by dispensing little quantities of water. This can be achieved in most cases by means of a labyrinth inside the drip emitter.

**Micro-Irrigation above Soil Surface**

These systems can be placed both directly above the ground and on supporting structures.

Different drip-pipes are used in vegetables growing, also under plastic mulch. These can be more or less rigid. Examples of flexible dripping pipes are: the perforated hose, double-cavity hose and pipes with external drip emitters, whereas rigid systems are "*in-line pipes*" and "*integral-pipes*" (the first containing drip emitters filling the whole section of the pipe, the second containing emitters welded inside, filling only a part of the section of the pipe). For improving the distribution efficiency of water, self-compensating emitters maintaining a constant pressure of supplied water have been developed. In some cases these emitters are joined with capillary mats. This association allows saving a lot of water and nutrients, compared with the oversupply in other systems.

**Sub-Surface Irrigation**

Though initially expensive and not suitable for many areas, the economical advantages of drip irrigation can be further enhanced by placing the irrigation pipes about 10 centimeters below the soil surface. Thus, the water goes straight to the roots of the plants. Evaporation is greatly reduced, and there is no opportunity for surface runoff. This system can also be used for the efficient supply of fertilizers.

**Irrigation Management for Water Efficiency**

Incorporating a crop demand-dependent irrigation schedule saves water without affecting crop yields. In order to efficiently apply water to the root zone, estimate the water demand based on soil type, precipitation, crop needs and soil moisture retention. The process for developing an irrigation schedule is described below.

- Determine your soil type. Soil characteristics help determine effective irrigation application rates, durations and frequencies. For instance, sandy soils may require more frequent but shorter-duration applications.
- Determine weekly precipitation amounts. Install a rain gauge in a central location. Although local radio and TV weather services can give you general precipitation rates for the week, site-specific information is more accurate.
- Monitor soil moisture to determine whether irrigation is necessary. If the soil moisture content is adequate for the crop's water quantity needs, no additional water application is required. Soil moisture can be measured with tensiometers, electrical resistance blocks ("gypsum," "ceramic" or "moisture" blocks) or neutron probes.
- Measure the output from your irrigation devices. Use flow meters or gauged water pans to measure the output of sprinklers and drip irrigation heads.
- Combine the information above to determine a week-by-week irrigation schedule. Update the schedule as weather and soil moisture conditions change.
- Recheck soil moisture 1-2 days after irrigation to determine depth of applied water and uniformity. If water penetration is too deep, too shallow, or spotty adjust your irrigation schedule to correct it.

## 3.2.5. Integrated Nutrient Management in Nursery

**Integrated Nutrient Management (INM):**

Integrated Nutrient Management differs from the conventional nutrient management by more explicitly considering nutrients from different resources, notably organic sources, nutrients carried over from previous cropping season, the dynamics, transformations and interactions of nutrients in the soils, interaction between their availability in the root zone and during growing season in relation to the nutrient demand by crop.

**Integrated Plant Nutrient system (IPNS):**

IPNS is the maintenance of soil fertility through plant nutrient supply to an optimum level for sustaining the desired productivity through optimization of benefits from all possible sources in an integrated manner.

The INM is a practice for soil fertility management:

- It enhances the availability of both applied and native soil nutrients during the crop season.
- It synchronizes the nutrient demand set by the plants both in time and space with supply of nutrients from soil and applied nutrient pool.
- It sustains and enhances the physical, chemical, biological properties related to the soil health.
- It arrests degradation of soil water and environmental quality by minimizing the wastage of nutrient to water bodies and atmosphere.

**Major Components of INM** can be grouped in to three broad groups**:**

1. Organic Manures
2. Inorganic Fertilizers
3. Biofertilizers

**1. Organic Manures:**

Bulk organic manures have been the major traditional means of sustaining plant nutrients in the soil throughout history and equally as important today.

(**A) In-situ Manuring by Animals:** This is the widespread traditional practice in areas where cattle, buffalo, sheep, and goat are kept during night on open land and latter ploughed directly to be incorporated in the soil.

**In-situ Manuring by Plants (Green Manuring):** From the time immemorial, the turning in green manuring crop especially legume for improving the soil productivity is popular among the farmers.

If the green manure crop is grown and incorporated in same field, this type of green manuring is referred to as green manuring in situ. Leguminous crops produce around 15 ton biomass per hectare which adds about 50 kg nitrogen per hectare into the soil.

**Commonly Grown Green Manure Crops are:** Dhaincha, Indigo, Rostrata, Sesbania, Wild indigo, Sunhemp and Pillipesara

**Green leaf Manure**: It refers to incorporation of green twigs and leaves collected from shrubs and tree grown on bunds, wasteland and forests. e.g. Karanj, Neem, *Glyricidia*. On dry weight basis the nitrogen content of green leaf manure crop various from above 1.5-2.5%.

**Ex-situ Organic Manuring**

**Livestock and Human Waste:** Cattle and buffalo dung and urine (FYM), other livestock and human excreta, byproduct of slotter house and animal carcass such as blood, meat, bones, horns, hooves, leather and hair waste.

**Crop Residues Tree Waste and Aquatic Weeds:** Crop waste of cereals, pulses and oil seeds, stalks of corn, cotton, tobacco, sugarcane, trash leaves of jute, arecanut, forest litter. Crop residue average contains 0.5% N, 0.6% P and 1.5% K.

**Urban and Rural Waste:** Urban and Rural solid waste Compost and urban liquid waste as sewage and sludge contain an average of 0.5-1.0 N, 0.4-0.8 P, 0.8-1.2 K

**Agro Industrial Byproducts:** Oil cake (3.0-7.0% N, 1.5-3.0% P, 1.5-2.5% K), paddy husk, saw dust, bagasse and press mud, fruit and vegetable waste, cotton, wool and silk waste, and tea, coconut, tobacco waste.

**2. Inorganic Fertilizers**

Nutrient needs of improved cultivars demand addition of large quantities of plant nutrient due to their high yield potential. Organic manures and biofertilizers are incapable of meeting the entire nutrient requirement of the plants individually. It is very necessary to tap all the available sources of nutrients in order to fulfill the entire nutrient requirement of the plants. Inorganic fertilizers play a vital role in satisfying the nutrient requirement of the plants.

It has been adequately established that the efficiency of inorganic fertilizer can be greatly increased through its integration with organic manure. Increasing efficiency of applied fertilizer through its integration with organic manure therefore appears to be an ideal way for sustained crop production.

**3. Biofertilizers**

Preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphorus solubalizing or cellulytic microorganisms. Biofertilizers are used for application to seed, soil or composting with objective of increasing the numbers such microorganisms and accelerate microbial processes. To augment the extent of the availability of nutrient in a form that can be easily assimilated by plants.

**Advantages of Biofertilizers**

- Reasonably eco friendly method which are compatible with chemical fertilizers.
- The beneficial effect of VAM on plant growth as mostly attributed to an increase in the uptake of nutrients especially phosphorus and result in enhancing the crop growth and increasing the yield.

- Improves the seed germination as microbes synthesize growth promoting substances. It is a cheap source of meeting crop nutrient requirement partially.

**Disadvantages of Biofertilizers**

- Biofertilizers alone cannot satisfy the total nutrient requirement of crops.
- Proper precautions should be taken while purchasing, storage, using the biofertilizers.
- Biofertilizers are not easily available in the local markets and there is a risk of obtaining substandard quality of biofertilizers from the market.

**Types of Bio Fertilizers & Beneficiary Crops**

| ***Bio Fertilizers*** | ***Beneficiary Crops*** |
|---|---|
| Rhizobium | Crop specific bio fertilizers for legumes like Groundnut, Soybean, Red gram, Black gram, Green gram, Cow pea, Yard long bean. |
| Azotobacter | Cotton, Mulberry, Plantation crops, Barley, Ragi, Jowar, Mustard, Safflower, Niger, Sunflower, Tobacco, Vegetables, Spices, Condiments, Ornamental flowers. |
| Azospyrillum | Sugarcane, Vegetables, Maize, Pearl Millet, Rice, Wheat, Fodder crops, Oil seeds, Fruit and Flower. |
| Blue Green Algae | Rice |
| Azolla | Rice |
| Phosphate Solubalizing Microorganisms | All crops. |

## 3.3 Glossary

**Biofertilizers:** Preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphorus solubilizing or cellulytic microorganisms used for application of seed, soil or composting with objective of increasing the numbers such microorganisms and accelerate microbial processes to augment the extent of the availability of nutrient in a form that can be easily assimilated by plants.

**Compost:** Compost is a combination of decomposed plant and animal materials and other organic materials that are being decomposed largely through aerobic decomposition.

**Essential Plant Nutrient:** A nutrient essential for proper growth and development of plants.

**Fertilizer:** Any natural or manufactured material, dry or liquid, added to the soil in order to supply one or more plant nutrients is called a fertilizer. The term generally used for commercially manufactured materials.

**Foliar Fertilization:** Fertilization of plants or feeding nutrients to plants by applying chemical fertilizers to the foliage. This is also known as foliar feeding or spray fertilization.

**Manures:** The excreta of animals including dung and urine, with straw and other materials. The decomposed manure is called farm yard manure.

**Nursery:** A nursery is a place where plants are propagated and grown to usable size.

**Oil cakes:** When oil is extracted from oil seeds the remaining solid portion is called oil cakes.

**Sludge:** The solid portion of sewage.

**Soil Fertility:** Soil fertility refers to the inherent capacity of a soil to supply nutrients to plants.

**Trace elements:** Micronutrients / minor elements.

## 3.4 Points to Remember

1. The deficiency of nutrients is specific to the element and it can be corrected only by supplying that particular element.
2. NPK are called as the Major Primary Nutrients and Ca, Mg and S are called as secondary nutrients.
3. Plant Nutrient showing deficiency on older or lower leaves are Nitrogen, Phosphorous, Magnesium, Potassium, and Zinc.
4. Plant Nutrient showing deficiencies on younger leaves are Calcium, Boron, Copper, Manganese, Sulphur, and Iron.
5. Sand consists of small rock grains (0.05-2.0 mm in diameter) formed as result of the weathering of various rocks.
6. Peat consists of the remains of aquatic, marsh, bog or swamp vegetation, which has been preserved under water in a partially decomposed state.
7. Vermiculite is micaceous mineral, which expands markedly when heated. It chemically a hydrated magnesium- aluminium-iron silicate.
8. Perlite is gray material of volcanic origin mined from flows and has natural reaction with no buffering and no cation exchange capacity and no mineral content.
9. Coco peat is also called as coco dust. It is most popular growing media available these days.
10. Chemical properties tested while assessing the quality of water for irrigation are Total Soluble Salt Concentration, Sodium Absorption Ratio, Residual Absorption Carbonate and Boron Content.
11. Major components of integrated nutrient management in plant s are Organic Manure, Inorganic Fertilizers and Biofertilizers.

## 3.5 Self Check Questions

1. Enlist the nutrients required for plant growth and development.
2. State the deficiency symptoms of nitrogen, phosphorous and potassium in plant growth.
3. Enlist the growth media and state the qualities of good rooting media.
4. Write a note on integrated nutrient management (INM)

## 3.6 Do it Yourself

1. Visit an agro-service center in your area and list out the manures, fertilizers and biofertilizers available in the center along with their selling price
2. Visit a horticultural nursery in your area and enlist the growth and rooting media used in the nursery. State the merits and the demerits of available rooting media.
3. Write a note on integrated nutrient management in horticultural nursery plants based on your observations in a horticulture nursery.

# Unit 4: Plant Protections in Nursery

***Index***



## 4.1 Introduction

The need to produce more food to feed the increasing population will continue. The systems and technologies that are being used now may have to be modified and new technologies adopted in order to ensure that this goal can be achieved. Pests are a major bottleneck in attaining this goal. Pesticides will continue to play an important role in protecting the crops from pests in the foreseeable future, as there are no practical alternatives at the moment. However, of late there have been many encouraging developments that give hope for the future.

The old concept of 'immediate kill' or 'kill all' chemicals will have to give way to the concept of chemicals that are less hazardous to natural enemies of pests like parasites and predators and keep pests at manageable levels.

**At the end of this unit, you will be able to know and understand:**

- Define and identify the Pest, Disease, Weeds in a Nursery.
- Enlist the various methods of control of the diseases, pests and weeds.
- Describe the Integrated Pest Management in a Horticulture Nursery.

## 4.2 Content

### 4.2.1 Pest Management in Nursery

If you ever visit a garden or crop field you will come across cuttings on leaf margins, holes in leaves, chewed and damaged parts of plants, spots on leaves etc. They are due to the attack of various organisms which are known as pests. A pest is any organism, animal, plant or microorganism that causes damage to the plants, animals or

human beings. The word pest is derived from the Greek word ‘pestis’ which means to annoy, to disturb or to destroy.

The Organisms designated as 'pests' compete with humans for food, fiber and shelter; transmit pathogens; feed on human food and threaten human health, comfort or welfare.

**Major Pest Groups**

The major pests of agricultural importance can be broadly divided into the following groups:

**Insect Pests:** Insect pest and mites cause heavy damage to crops. Amongst the one million species of insects about 200 species can be termed as serious pests in agriculture.

**Plant Diseases:** Fungi, bacteria and viruses cause diseases in plants and insects. Nematodes are also sometimes classified as pathogens.

**Garden Snails:** They are called molluscs and become pests around home gardens, in lawns, greenhouses and ornamental plantings.

**Weeds:** These are the plants that either compete with crop plants thus affecting yield and quality, or may interfere with the use of land and water resources.

**Vertebrate pests:** These are mainly rodents, birds and some other mammals like bats rabbits etc. that cause damage to crops and stored products.

**Pest Control**

A nursery man adopts various methods to protect seedling from the pests. This activity is called as is the applied control or pest control. Traditionally pest control means the use of chemical pesticides. In the present day context, pest control includes the use of all those methods which are employed for preventing pests and diseases without disturbing environment.

**Methods of Pest Control**

Important methods of pest control are briefly described below:

1. **Cultural Method:** It refers to manipulation of farm practices to check the pests. Some of the important cultural methods are: Crop rotations, Tillage methods (deep summer ploughing), High seed rate, Water management, Manipulation of date of sowing, and Trap cropping.
2. **Physical Method:** These methods involve modification of physical factors in the environment to minimize or prevent pest problem. Various physical methods are: Temperature manipulation, Moisture manipulation, Light manipulation, and Use of sound.
3. **Mechanical Method:** This refers to the use of mechanical implements and devices for removal and destruction of pests. Some of them are, Screens, traps, nets and suction devices, Hooking devices with iron rod in the hole bore by the insect, Banding with grease or polythene sheets on stem, Covering of seedling with net; and trenching and water barrier-ant pans.

4. **Legal or Regulatory Method:** This refers, to the legal restrictions proposed by the Central and State Governments to check the spread of pests. The regulations such as Inspection and quarantine and Destructive Insect Pests Act can be enlisted under this heading.
5. **Resistant Varieties:** Use of resistant varieties help in avoiding or tolerating or recovering from pest attack. Resistant varieties have been identified against various pests in a number of crops.
6. **Biological Method:** This method refers to the use of natural enemies of pests viz. parasites, predators and microbes or pathogens (bacteria, virus, nematodes, fungi, protozoa etc.) so as to suppress the pest species. Biological control program can be carried out in the following ways: conservation and encouragement of indigenous natural enemies, importation of exotic natural enemies and mass rearing and releases of parasites/predators and microbes.
7. **Chemical Control:** The use of chemicals for the control of pests is known as chemical control. Pesticides are the chemicals used to kill or repel or attract or sterilize pests.

   Pesticides are without any doubt an effective means of killing pests quickly and on demand. No other control method provides users with an immediate and visibly effective means of pest control. Over the years, the indiscriminate use of pesticides bas resulted in a number of serious detrimental effects on the environment.
8. **Use of Botanical Pesticides:** These include the use plant products with a potential to control pests. Many plant products (leaf extracts, oils and cakes) have the property of inhibiting the development of pests and diseases. The plant extracts and oils are sprayed on the crops. Neem oil, neem cake and other neem based formulations have been found effective against pests.

**Use of Pesticides in Pest Control**

The development of effective, economical pesticides has had a profound effect on man's continual battle with pests. In many cases pesticides have been incorporated as tools in well planned pest control programmer without serious hazards to humans or to the environment. Application of pesticides must be done at proper time, at right rate by using suitable equipment. The pesticides are applied on seeds, foliage and other parts or in soil against different pests and diseases. The various methods of pesticides application are Seed treatment, foliar application, Soil application, Granular application, Seedling root dip, Fumigation, Baiting etc.

| ***Pest*** | ***Damage*** | ***Management*** |
|---|---|---|
| Pseudostem Borer | The grubs bore into the stem and feed within the stem. | Application of Carbaryl WP (0.1%) also controls the pest population. |
| Red Pumpkin Beetle | They make holes in cotyledonary leaves of cucurbits. As a result the seedlings die in the younger stage | Spraying Carbaryl (4 g/liter of water) or Metacid (1ml/liter of water) |

| *Pest* | *Damage* | *Management* |
|---|---|---|
| Aphids | Aphids damage the plants by sucking the leaf sap in young stage, cotyledonary leaves crinkle and in severe cases the plants withers off. | Spraying Malathion (0.1 %) or Metasystox (0.1-0.2%) |
| Jassids | Both nymphs and adults suck the sap from the lower surface of the leaves. The infested leaf curl upward along the margins, which may turn yellowish and show, burnt up patches. | Spraying Malathion (0.1%) or Dichlorvos (0.05%) |
| Leaf Roller | Caterpillars roll leaves and feed on chlorophyll while remaining inside the folds. The folded leaves wither and dry up. | Spraying of Carbaryl (0.1%) or Malathion (0.05%) |
| Red Spider mite | Different stages of mites are found in colonies covered by white-silky webs on lower surface of leaves. Nymphs and adults suck cell sap and white patches appear on leaves. Affected leaves become mottled, turn brown and fall. | Acaricides like Omite (0.05%) and Wettable Sulphur (0.3%) gives effective control of mites. |
| Mealy Bug | Nymphs and adults of mealy bugs suck sap from the leaves, tender shoots and the fruits. A heavy black sooty mould may develop on the honeydew like droplets secreted by mealy bugs. | Spraying of insecticides like Dichlorvos (0.02%) or Chlorpyriphos (0.05%) with fish oil rosin soap was found to control the insect population. |
| Root-Knot Nematodes | The affected plants show the development of galls on the roots. The plants become stunted and the leaves show chlorotic symptoms. | Treating the nursery beds with Phoret @ 5 g a.i./$m^2$ or Neem Cake 1 kg/$m^2$ Select resistant varieties. |
| Cabbage Diamond back Moth | Severely affected leaves are completely skletonised. | Spraying the crop with Malathion (0.1%) or Profenofos (0.25-0.5 kg a.i./ha) |
| Thrips | Nymphs and black adults feed on tender leaves causing silvering, mottling and distortion of leaves. | Soil application of thimate twice at 15 days interval at 5 gm/bed and also take spray. |
| Leaf Folder | Larva fold leaves together and feed on chlorophyll. The affected leaves get skeletonized and dry. | Two or three sprays of Quinalphos @0.05% |

| *Pest* | *Damage* | *Management* |
|---|---|---|
| Leaf Miner | Larvae attack tender leaves and feed in the epidermal layers of the leaf by making serpentine mines in which air gets trapped and gives them silvery appearance. | Spraying the plants with Quinalphos @0.05% |
| Leaf Eating Caterpillar | Larvae feed on lower surface of leaves by scraping while greenish-brown mature larvae feed voraciously during nights on these leaves. | Spraying of Quinalphos @0.05% or Carbaryl @ 0.1% or Chlorpyriphos @0.05% |
| Cutworms | The tender plants are found damped at ground level during the night Young larvae feed gregariously on foliage but later segregate and enter into soil. | Soil application of Phorate (1kg a.i./ha) |
| Whitefly | The damage by whitefly also leads to yellowing of leaves and stunted growth, in severe cases leading to shedding of leaves | Spraying Triazophos 40 EC (1.5 ml/ L of water) + 1.0 ml of Dichlorvos 76 EC per litre of water. |

## 4.2.2 Diseases Management in Horticulture Nursery

Agricultural production of the world sustains annual loss of about 20 to 30% on an average due to plant diseases on different crops and in different countries. Plant diseases is one of the major bottlenecks in Agricultural Production in irrigated crops, monoculture cultivations, widely grown rainfed crops as well as in plant nurseries.

**Favorable Conditions for Diseases Infestation**

Plant diseases are caused by various sources like micro-organisms, including fungi, bacteria, viruses, mycoplasmas, etc. or may be incited by physiological causes including high or low temperatures, lack or excess of soil moisture and aeration, deficiency or excess of plant nutrients, soil acidity or alkalinity, etc.

The causative agents of disease in green plants are in thousands and include almost every form of life. But primary agents of disease may also be inanimate. Thus nonliving (abiotic) agents of disease include mineral deficiencies and toxicities, air pollutants, biologically produced toxicants, improperly used pesticide chemicals, and other environmental factors as wind, water, temperature and sunlight.

**Abiotic factors:** Nonliving agents certainly qualify as primary agents of disease; they continuously irritate plant cells and tissues; they hamper the physiological processes of the plant; they evoke pathological responses that later show up as symptoms and characteristic of the different diseases. The abiotic agents of plant disease are termed noninfectious and the diseases they cause are termed noninfectious diseases.

**Micro-organisms:** The micro-organisms obtain their food either by breaking down the dead plant and animal remains (saprophytes) or by attacking living plants and animals (parasites). In order to obtain nutrients, the parasitic organisms excrete enzymes or toxins and kill the cells of the tissues of the host plant. These toxins kill or damage whole plant or a part of it, and cause considerable disturbance in its normal metabolic processes.

**Parasites:** The parasites are one of the major factors causing plant diseases. Parasites are those living organisms which colonize the living tissues of the host-plant. These diseases can be transmitted from plant to plant. These biotic agents are, therefore, infectious, and the diseases they cause are termed infectious diseases.

**Ability to Produce an Inoculum**

The parasitic pest must produce an inoculum, some structure that is adapted for transmission to a healthy plant and thus can establish a parasitic relationship with the host. For example, inocula for viruses are the viral particles (virions); for bacteria, the bacterial cells; for fungi, various kinds of spores or the hyphal threads of mold; for nematodes, eggs or second-stage larvae.

**Media for Transportation of Inoculum**

The inoculum must be transported from its source to a part of a host plant that can be infected. This dispersal of inoculum to susceptible tissue is termed inoculation. Agents of inoculation may be insects (for most viruses, mycoplasma-like organisms, bacteria and fungi), wind and rain (for many fungi).

**Wounds and Natural Openings**

The parasite must enter the host plant to cause an infection. A parasite can enter the host through the following means, through wounds, through natural openings, or by growing directly through the unbroken protecting surface of the host. Viruses are injected into the plant through the proboscis of insects feeding on the juice of the host plant. Bacteria enter through wounds or natural openings like, stomates, hydathodes, and lenticels. But many fungi can penetrate plant parts by growing directly through plant surfaces, exerting enormous mechanical pressure and possibly softening host surfaces by enzymatic action.

**Availability of Food**

Availabitlity of food or nutrition within the body is essential for the parasite to grow within the host. This act of colonization is termed infection. The parasite damages the cytoplasmic memberanes of the host cells and makes the membranes freely permeable to solutes for nourishment of the parasite and parasitism. This is achieved by enzymatic attacks of the parasite upon carbohydrates, proteins and lipids inside the host cell. The breakdown products of such complex molecules would diffuse across the damaged host-cell membranes and be absorbed by the parasite in the form of sugars and amino acids.

**Temperature Effects**

The growing season of the parasite is affected by the temperatures of the surrounding. Many pathogen systems of cereal rusts in particular are affected by temperature. At times about half of the wheat cultivars showed differential resistance expression when tested against isolates of brown rust (leaf rust), either effective at 10°C and not at 25°C or vice versa.

**Method of Disease Control in Nursery**

**(A) Preventive Measures**

**Cultural Practices**: Cultural practices usually influence the development of disease in plants by affecting the environment. Such practices are intended to make the atmospheric, edaphic, or biological surroundings favorable to the crop plant, unfavorable to its parasites. Cultural practices that lead to disease control have little effect on the climate of a region but can exert significant influence on the microclimate of the crop plants in a field. Three stages of parasite's life cycle namely, Survival between crops, production of inoculum for the primary cycle and inoculation can be controlled by following preventive measures.

1. **Survival between Crops**: Organisms that survive in the soil can often be controlled by crop rotations with unsusceptible species. Catch crop has been used to control certain nematodes and other soil-borne pathogens. Soil-borne plant pathogens can be controlled by biological methods. Plant parasites may be controlled by encouraging the growth of antagonistic organisms. This can be achieved by adoption of cultural practices such as green manuring and the use of appropriate soil additives. Soil-borne plant parasites may also be killed during their over-seasoning stages by such cultural practices as deep ploughing, flooding, and frequent cultivation and fallow. Plant diseases caused by organisms that survive as parasites within perennial hosts or within the seed of annual plants may be controlled therapeutically.
2. **Production of Inoculum for the Primary Cycle**: Environmental factors (particularly temperature, water, and organic and inorganic nutrients) significantly affect Inoculum production. Warm temperature usually breaks dormancy of over seasoning structures; rain may leach growth inhibitors from the soil and permit germination of resting spores and special nutrients may stimulate the growth of seasoning structures that produce inoculum.
3. **Dispersal of Inoculum and Inoculation**: Cultural practices that exemplify avoidance are also effective in avoiding dissemination. Dispersal can also be avoided over a larger span with the help of plant quarantine. Plant quarantine is the legally enforced stoppage of plant pathogens at points of entry into political subdivisions.
4. **Sample Inspection**: One of the preventive measures to control the diseases is the use of sample inspection method. Laboratory evaluation of the representative sample drawn by the certification agency for the determination of germination, moisture content, weed seed content, admixture, purity, seed-borne pathogens.

**(B) Control Measures**

**Chemical Control**: The pesticide chemicals that control plant diseases may be used in different ways, depending on the parasite to be controlled and the circumstances required for parasitic activities. Relatively insoluble protective fungicides are applied repeatedly to the green leaves of potato plants to safeguard them from penetration by the fungus of late blight. Also, systemic fungicidal chemicals may be used therapeutically. The oxathiin derivatives that kill the smut fungi that infect embryos is therapeutic. The Benomyl which has systemic action against powdery mildews and other leaf infecting fungi is also therapeutic in its action. Volatile fungicides are often useful as soil-fumigating chemicals that have eradicative action.

The chemical control of plant diseases is classified in three categories: seed treatments, soil treatments and protective sprays or dusts.

1. **Seed Treatments**: Chemical treatments of seed may be effective in controlling plant pathogens in, on, and around planted seed. Seed treatment is therapeutic when it kills bacteria or fungi that infect embryos, cotyledons, or endosperms under the seed coat. Seed treatment is called eradicative when it kills spores of fungi that contaminate seed surfaces. Seed treatment is protective when it prevents penetration of soil-borne fungi into seedling stems.

   Seed treatment is of two types; viz., physical and chemical. Physical treatments include hot-water treatment, solar-heat treatment, etc. Chemical treatments include the use of fungicides and bactericides.

**Seed Treatment of Mango Stones with Carbendazim fungicide**

   These fungicides are applied to seed by different methods. In one method, the seed in small lots is treated in simple seed-treaters. The seed-dip method involves preparing fungicide suspension in water and then dipping the seed in it for a specified time.

2. **Soil Treatments**: Soil-borne plant pathogens greatly increase their populations as soils are cropped continuously, and finally reach such levels that contaminated soils are unfit for crop production.

Chemical treatments of soil eradicate the plant pathogens and offer the opportunity for uninterrupted agricultural uses by rapid reclamation of infested soils. Preplanting chemical treatment of field soils for the control of nematode-induced diseases, fumigation of seedbed and greenhouse soils with methyl bromide, etc is commonly practiced to eradicate weeds, insects, and plant pathogens.

Field applications of soil-treatment chemicals for fungus control are usually restricted to treatments of furrows. Formaldehyde or captan applied against sclerotia-producing fungi that cause seedling blights, stem rots, and root rots of many nursery seedlings. Other soil-treatment fungicides are vapam and "Vorlex". Soil treatments are made at the time of planting are most effective against parasitic attacks that come early in the growing season.

1. **Protective Sprays and Dust**: Protective fungicides prevent germination, growth and penetration. In order to use protective fungicides effectively, the farmer must not only select the right fungicide for the job but also apply it in the right amount, at the right times and in the right way. Too little fungicide fails to control disease; too much can prove toxic to the plants to be protected. The nurseryman and applicator, therefore, must always follow use instructions to the latter. Timing of applications is also critical.

| **Disease** | **Symptoms and Damage** | **Management** |
|---|---|---|
| Anthracnose | Regular to irregular spots on leaves with dark margins and grayish centre. | Spary Carbendazim/Bitertanol/ Thiophavate methyl, Calixin, Kavach/ Rovral (2 g/*l*.) in humid weather |
| Bacterial canker | Cankerous spots on leaves | Apply Copper oxycholride during rainy season |
| Powdery mildew | White mealy growth on leaves | Wettable sulphur Carbendazim /Bitertanol / Thiophavate methyl, Calixin, Kavach/Rovral (2 g/*l*.) in September-March |
| Downy mildew | Pale-olive spots with milky white mycelium on the under surface of leaves | Apply Copper oxychoride, contact fungicide should be apply at 3-7 days interval and systemic fungicide at 10-15 days intervals. |
| Rust | Pale yellow pustules of uredospore are prominent on under surface showed necrotic pin head lesions. | Spraying Chlerothalonil (2 g/l) or Biteranol (1 g/l) are recommended |
| Damping off | The infections take place at the base of the young stems or at the soil level. Tissue becomes water soaked and rapidly collapse thus topping the seedlings. These | Treat seed/soil/media with Captaf/ thirum/ Tricoderma etc. |

| Disease | Symptoms and Damage | Management |
|---|---|---|
| | pathogens cause pre- and post emergence damping off and wire stem of seedlings. It causes mortality of seedlings. | |
| Stem rot/ foot rot/ collar rot | Rooting of seedling stem near collar region | Spray Kavach/Rovral/Metalaxy/Mancozeb/ Aliette (2 g/l) |
| Leaf spot | Dark brown to light brown, tiny pustules on leaf surface, the pustules soon enlarge and turn blakish in the centre | Spray Carbendazim/Bitertanol/ Thiophavate methyl, Calixin, Kavach/ Rovraal (2 g/*l*.) in rainy season/ November |
| Wilt | The foliar are yellowing and production of crookneck shoots. The leaves and shoots wither and become brownish. Stems when cut open show brown discoloration at the vascular region. | Soil fumigation and treating the nursery beds with benlate or with Thiophanate methyl and using *Tricoderma* etc. |

**Biological Control Measure**

Biological control is defined as the use of a living organism to control or manage another living organism. Natural enemies include parasites, predators, fungi, nematodes and viruses. Most biological control programs are directed at insects and mites. However, plant disease suppressive composts are being used to effectively reduce problems with certain root rot pathogens. In addition, new products are being introduced for biological control of root and foliar diseases.

Natural enemies are often used similar to a regular fungicide application program; that is, introduced on a regular basis. Even more than with fungicide, disease management will fail if pest populations are too high when the natural enemies are introduced. Biological controls are not rescue treatments. Often, disease pathogen populations will not decline and probably will even increase for several weeks to two months after introducing natural enemies.

## 4.2.3 Weed Management in Horticulture Nursery

Weed management is an important component of plant protection for improving the production potential of nursery. It includes management of the weeds in such a way that the nursery sustains its production potential without being harmed by the weeds. Weeds are the plants that grow without human efforts and are not wanted. They grow in the fields where they compete with nursery plant for water, soil nutrients, light, and space. Proper weed management is a pre-requisite for obtaining higher input efficiency. Weeds also act as alternate hosts that harbor insects, pests and diseases and other micro-organisms. Some weeds release growth inhibitors or poisonous substances into the soil. These may be harmful to the nursery plants, human beings and livestock. Weeds reduce

the quality of marketable nursery produce, leading to increased expenditure on labour, equipment and chemicals for their removal.

Weed management is done through the mechanical, cultural and chemical means. Use of biological control methods in nursery is being considered, but still not much in use. Use of herbicides is an important method of weed-management technology. New hand-tools and implements have also been designed to assist in weed management in nursery.

Nursery plants are exposed to severe competition from weeds. Most of these weeds are self-sown and they provide tough competition to the nursery plants due to their faster growth than the growth of nursery plant in their initial stages.

**Characteristics of Weeds:**

Weeds are also like other plants but have special characteristics that tend to put them in the category of unwanted plants.

- Most of the weeds especially the annuals produce enormous quantity of seeds.
- Weeds have the capacity to withstand adverse conditions in the nursery field.
- Weed seeds remain viable for a longer period.
- Weed seeds have a tremendous capacity to disperse from one place to another through wind, water and animals including man.

**Principles of Weed Management:**

In order to reduce the negative implications of weeds on the quality and quantity of nursery plants, weeds have to be controlled efficiently. To do the job successfully, a thorough understanding of weed biology in the crop environment becomes essential. Prevention, control and eradication are the keys in weed management.

**Prevention:** Prevention involves procedures that avoiding the establishment of weeds in areas not inhabited by them. These practices restrict introduction, propagation and spread of weeds on a local or a regional level. Preventive measure include cultural practices such as,

- Seed cleaning,
- Use of weed-free seed,
- Manure and machinery,
- Controlling weeds on field bunds, and irrigation canals,
- Screening irrigation water,
- Restricting movement of farm animals, etc.

Prevention is highly cost effective, as establishment of any new weed is going to create problem for many year.

**Eradication:** Eradication is the total elimination of a weed species from a nursery field, area or region. It requires the complete removal of seeds and vegetative parts of a weed species in a defined area. It is usually attempted only in small area or areas with high value crops because of the difficulty and high costs associated with eradication practices.

**Control:** Control practices reduce or suppress weeds but do not necessarily result in the elimination of any particular weed species. Weed control, therefore, is a matter of degree and depends upon the goals of the people involved, effectiveness of the weed control tactic used and the abundance and tenacity of the weed species present. There are 4 general methods of weed control: Physical, cultural, biological and chemical.

**(A) Physical Methods:** Hand pulling or hand weeding, hoeing, tillage, mowing, burning, flooding, smothering etc. are examples of physical methods of weed management. These methods involve the use of physical energy through implements either manually or bullock drawn or power operated. Nurseryman mostly resort to hand weeding with the help of hand chisel (khurpi), hand hoe, spades, etc. It is one of the most commonly used methods but is back breaking, time consuming and costly effort.

**(B) Cultural Methods:** Weeds are better competitors than nursery plants for light, water, nutrients and space. However, good nursery practices manifest the conditions so as to enable the nursery plants to compete with the weeds successfully. Such practices can reduce the interference of the weeds to the minimum and optimize the nursery production. Quality seed with good germination will give the nursery seedling a vigorous and close stand, and would enable the seedling to steal a march on the weeds. Varieties well adapted to a season will complete better with the weeds than those poorly adapted to it. Selection of crops which are quick-growing and short duration varieties with larger leaf area and good branching or tillering ability is essential to compete with the weeds. Proper seed rate, depth, time and method of sowing, and the use of the most appropriate method of irrigation and manuring can also minimize the losses due to weed infestation.

(**C) Biological Method:** In this method, the natural enemy of a weed plant is used to control the weed. The requirements for the success in this method are:

1. The weed species must have been introduced and in the process of introduction must have been freed from its natural parasites or predators.
2. The natural predators and parasites must be introduced to prey upon or parasitize the weeds but they in turn must be freed from parasites in order to carry out their work for destruction unhampered.
3. The destructive agents must be highly specialized so they these are able to thrive even under starvation condition on agricultural plants of the new habitat. Root-borers, stem-borers and internal seed-or fruit feeders are more highly specialized than the foliage feeders.

An outstanding example of biological control of plant is that of prickly pear (*Opuntia spp*.) in Australia. Another noteworthy example is of destruction of Lantana with the help of Telenemia scruplosa. Attempts are under way for the biological control of nutgrass in Hawaii. Water hyacinth can also be controlled through the use of Neochetina bruchi and N. eichhorniae. Successful control of Parthenium hysterophorus has been reported with the help of Mexican beetle Zygogramma bicolorata. It is necessary not only to identify a predator but also to analyze the other effects of introducing such a predator into a new territory.

(**D) Chemical Method:** Weed management in horticultural nursery constitutes a major input in their production of seedling. Losses due to weeds are highest in least developed crop production systems and lowest in most highly developed ones. In tropical and subtropical countries, 70% of the labour input is diverted for weeding. A broad spectrum of monocot and dicot weeds infests these crops. Their control measures are given in Tables 1, 2 and 3.

**Control Measures of Weeds Infesting Fruit, Vegetable and Flower Nursery Seedling.**

| ***Crop*** | ***Recommended herbicide*** |
|---|---|
| Mango | Diuron or Oxyfluorfen |
| Banana | Diuron / Simazine / Oxyfluorfen Paraquat /Glyphosate |
| Pineapple | Bromacil + Diuron |
| Grape | Oxyfluorfen or Diuron |
| Papaya | Fluchloralin or Butachlor or Alachlor |
| Citrus | Diuron |
| Guava | 2, 4-D or Paraquat or Diuron |
| Strawberry | Simazine or Chloroxuron |
| Cocoa | Basta |
| Coconut | 2,4-D or Ester or Diuron or Glyphosate |
| Coffee | Oxyfluorfen or Glyphosate |
| Oil palm | Gramuron (Paraquat+Diuron) |
| Cabbage | Oxyfluorfen or Fluchloralin |
| Cauliflower | Oxyfluorfen or Pendimethalin |
| Knol-khol | Fluchloralin or Butachlor |
| Tomato | Alachlor or Fluchloralin |
| Brinjal | Fluchloralin |
| Chilli | Alachlor or Butachlor or Fluchloralin |
| Onion | Fluchloralin |
| Cucurbitaceous crop | Alachlor or Butachlor or Fluchloralin |
| Rose | Diuron or Oxyfluorfen orAtrazine |
| Gladiolus | Fluchloralin |
| Chrysanthemum | Oxyfluorfen |
| Marigold | Simazine |
| Carnation | Oxadiazon |
| China aster | Oxyfluorfen or Diuron or Alachlor |

**Integrated Weed Management:**

Integrated Weed Management (IWM) approach aims at minimizing the problem of residue of herbisides found in plant, soil, air and water. An Integrated Weed Management may be defined as the combination of two or more weed-control methods at low input levels to reduce weed competition in a given cropping system below the economical threshold level. It has proved to be a valuable concept in a few cases, though much is still to be done to extend it to the grass root farmer level. An IWM involves the utilization of a combination of mechanical, chemical and cultural practices of weed management in a planned sequence, so designed as not to affect the ecosystem.

The nature and intensity of the species to be controlled, the sequence of nursery plants that are raised in the rotation, the standard of nursery plants to be produced, the time of availability of the resources used in the method and the economics of different weed-management techniques are some of the potent considerations that determine the success for the exploitation of the IWM approach.

## 4.2.4 Biopesticides Application in Horticulture Nursery

**Introduction**

Biopesticides are certain natural plant products that belong to the so called secondary metabolites that include thousands of alkaloids, terpenoids, phenolics and minor secondary chemicals.

Biopesticides have usually no known function in photosynthesis, growth or other basic aspects of plant physiology; however, their biological activity against insect pests, nematodes, fungi and other organisms are well documented. Every plant species has developed an inbuilt unique chemical complex structure for protection against pests. The plant kingdom offers us a diverse array of complex chemical structures and almost every imaginable biological activity. These biodegradable, economical and renewable alternatives are used especially under organic farming systems.

Crop losses due to insect pests and diseases are estimated to be more than 30 per cent in terms of agricultural crop produce. Though the crop productivity increases significantly due to use of mostly chemical pesticides, their continuous use contributed to increasing environmental threat to natural resources, wildlife, non-target beneficial species. It also results in development of pest resistance and resurgence of the pest attack. Mounting concern for environment has, therefore, led to evolve an alternate coherent pest management programme which is eco-friendly, self sustaining and yet provide effective management of pests and diseases. In this context the use of biopesticides or pesticides of microbial origin are becoming increasingly important.

**The Characteristics of Biopesticides:**

- Eco-friendly,
- Possess higher degree of host specificity,
- Genetically stable and do not pose the risk of resistance development,
- Compatible with biofertilizers and many agrochemicals,
- Can be exploited under the ambit of integrates pest management (IPM).

At present, more than 21,500 naturally occurring microbes or their metabolites are known to possess pesticidal properties. The sale of agrochemicals through out the world is currently estimated to be $ 26,800 million, whereas biopesticide sales are around $ 120 million. Biopesticides sales, however, are estimated to increase at a rate of 10 to 25 per cent per annum in contrast to static or shrinking world agrochemical market.

**Viral Biopesticides:**

Viral biopesticides of baculovirus group namely Nuclear Polyhedrosis Viruses (NPVs) and Granulosis Viruses (GVs) offer great scope as crop protection agents on high value crops such as cotton and vegetables against lepidopteran pests like *Helicoverpa armigera* Hbn. and *Spodoptera litura* Fabr. More than 500 *baculovisurses* (BVs) have been reported so far. Some of the insect pests from which occlusion viruses have been reported in India have great potential in IPM.

**HNPV infected Catterpilar of Tomato Fruit Borer**

**Bacterial Biopesticides:**

Many spore forming and non-spore forming bacteria are known to be effective against a wide spectrum of insects and pests. The crystalliferous *Bacillus thuringiensis* (Bt) has been found to be effective against several species of lepidopteran pests. Its insecticidal activity is primarily caused by parasporal crystal (delta endotoxin) produced during sporulation. The discovery of isolate capable of acting against coleopterans (*B. thuringiensis tenebrionis* and *B. sphaericus* against mosquito and *B. moritai* against dipteran insects has further extended the scope of bacterial insecticides. Several bacteria like, *Pseudomonas fluorescens, Bacillus subtilis, Streptomyces nigrifaciens, Agrobacterium radiobacter* and *Azotobacter spp.* are known to be potential bio-agents against several plant pathogen. Most of these bio-control bacteria are, however, in the stage of empirical application, either in the green house or in the field with a few exceptions. There are reports of bacterial bio-agents in enhancing the growth and greater root volumes of crop plants when applied as seed treatment or soil application. This

envisages that the responses may be as biofertilizer or by the control of some undiagnosed plant pathogens.

Recently, *Pseudomonas spp.* is being promoted as plant growth promoting rhizobacteria (PGPR). The mechanism of pathogen suppression by these bacteria includes substrate competition, niche exclusion, and production of siderophores, antibiosis and induced resistance.

**Fungal Biopesticides:**

Fungi unlike bacteria or virus do not require ingestion for infection; so sucking pests are also targeted by primary contact or by secondary uptake from sprayed vegetation. The pathogenesis begins with germination of conidia on the cuticle and penetration and development inside the host leading to death of host essentially under high humid condition.

**Why Choose a Biopesticide?**

- Human and environmental safety
- Alternatives to conventional pesticides
- Amenable to small-scale and local production in developing countries
- Increased public awareness of environmental and food safety
- Fundamental component of Integrated Pest Management
- Controls pests resistant to conventional pesticides

Biopesticides are pest management tools that are based on beneficial microorganisms (bacteria, viruses, fungi and protozoa), beneficial nematodes or other safe, biologically based active ingredients. Benefits of biopesticides include effective control of insects, plant diseases and weeds, as well as human and environmental safety. Biopesticides also play an important role in providing pest management tools in areas where pesticide resistance, niche markets and environmental concerns limit the use of chemical pesticide products.

Biological control is, generally, man's use of a specially chosen living organism to control a particular pest. This chosen organism might be a predator, parasite, or disease that will attack the harmful insect. It is a form of manipulating nature to obtain a desired effect. A complete Biological Control program may range from choosing a pesticide, which will be least harmful to beneficial insects, to raising and releasing one insect to have it attack another, almost like a "living insecticide".

**Popular Biopesticides used in Horticulture Nursery for Pest and Disease Management**

| ***Microorganism*** | ***Target pest/disease*** |
|---|---|
| **Insecticides** | |
| *Bacillus thuringiensis* (Dipel) | Caterpillar, larvae |
| *B. thuringiensis isrealensis* (Acrobe) | Mosquito, Black files |
| *B. thuringienis tenebrionis* (Novodor ) | Colorado potato beetle |
| *B. thuringiensis aizawai* (Certain) | Wax moth, Diamond black moth |

| ***Microorganism*** | ***Target pest/disease*** |
|---|---|
| *B. Sphaericus* (Spic biomass) | Dipteran insects |
| *B. papillae* (Doom) | Coleopteran insects |
| *B. moritai* (Labillus) | Dipeteran insects |
| *Verticillium lacanii* (Vertalee/Biolin) | Aphids, scale insects, mite, thrips |
| *Entomopthors* | Aphids, mites |
| *Numurea releyi* | Lepidopteran larvae |
| *Hirsutella thompsonii* (Mycar) | Citrus rust mite |
| *Beauveria bassiana* (Bovarin/Blorin) | Colorado potato beetle, Codling moth, Coffee berry borer |
| *Asohersonia aleyrodis* | Citrus scale insect |
| *Metarhizium anisopilae* (Metaquine) | Spittle bug |
| *Paeciliomyces lilacinus (*Bicon) | Nematodes |
| *Metarhizium flavoviride* | Locust, grasshopper |
| **Fungicides** | |
| *Trichoderma sp.* (BINAB-T) | *Chondrostereaum purpureum* |
| *T. harzianum* (F-stop) | *Pythium sp.* |
| *Trichoderma sp.* (Trichodermin) | *Botrytis, Pythium, Sclerotinia, Verticillium sp.* |
| *T. harzianum* 9T-39) (Trichodox) | *Botrytis cinerea* |
| *T. harzianum* (Tricho dowels) | *Rhizoctonia solani,Pythium sp.* |
| *T. viride* (Antagon TV) | *R. Solani, Macrophomina phaseolina* |
| *Tt. viride* (Sun-Derma) | *-do-* |
| *Trichoderma sp*. (Ecofit) | *-do-* |
| *T. virens* (Gliogard) | *Pythium ultimum* |
| *T. virens* (Soilgard 12 G) | *Pythium sp.* |
| *Amphelomyces quisqulais* | *Saphaerotjeca fuliginea* |
| *Pichia quiliermondii* | *Penicillium sp.* |
| *Aspergillus niger* AN-27 (Kalisena) | *Pythium, Fusarium, Macrophomina, Rhizoctonia, Sclerotinia sp.* |
| *Pseudomonas flurescens* | *Rhizoctonia solani, Scleritium rolfsii, Fusarium oxysporum, Legaeumannoyces graminis var. tritici* |
| *Streptomyees nigrifaciens* | *Tilletia caries, T. facticida, Drechslevsteres, Microdochium nivale* |
| *Agrobacterium radiobacter* | *Agrobacterium tumefacience* |
| *Bacillus subtilis* | *Fusarium udum, Fruit Rot of avocado, Xanthomonas malvacearum, Rhizoctonia solani* |
| **Nematicides etc.** | |
| Nematode trapping fungi Bacteria Mollusc parasitic nematode | *Myrothecium verrucaria, Paecilomyces lilacinus, Bacillus firmus, Pasteuria penetrans Phasmarhabditis hermaphrodita* |

| *Microorganism* | *Target pest/disease* |
|---|---|
| **Weed control** | |
| Fungi/ Bacteria | *Colletotrichum gloeosporioides, Chondrostereum purpureum, Cylindrobasidium leave Xanthomona campestris pv. poannua* |

***Crysopa carnea:*** **Bio-control Agent** **Lady Bird Beetle: Bio-control Agent**

***Trichogramma*** **Wasp: Bio-control Agent**

**Advantages of Biopesticides:**

- Biological control methods can be used as part of an overall integrated pest management (IPM) program to reduce the legal, environmental, and public safety hazards of chemicals.
- It may be a more economical alternative to some insecticides.
- Some biological controls are often very specific for a particular pest. Other helpful insects, animals, or people can go completely unaffected by their use.
- There is less danger of impact on the environment and water quality.

**Disadvantages Biopesticide:**

- It takes more intensive management and planning.
- It takes more time to show measurable effect;
- It requires more record keeping, more patience, and sometimes more education or training.
- Successful use of biological control requires a greater understanding of the biology of both the pest and its enemies.
- In some cases, biological control may be more costly than pesticides.
- Often, the results of using biological control are not as dramatic or quick as the results of pesticides use.

**Application of Biopesticide:**

Increasingly, biopesticides are being produced and sold as least toxic pest management tools. The increasing acceptance and sale of biopesticides has created need for better understanding of the method of its application.

If a decision has been made to use biopesticides to control pests, several considerations need to be made before proceeding.

- First, find a source of high quality biopesticides.
- Second, consideration should be made of how best to apply or release the biopesticides.

A number of challenges and limitations are posed when biopesticide is incorporated into a pest management program. The failure of control is not unique to biopesticides. The use of pesticides also involves challenges and limitations that can lead to product failure or poor performance. Environmental conditions such as temperature, rainfall, and wind can all affect the quality and effectiveness of the applied pesticide. Finally, it is important to make sure that the pesticide actually gets to the targets pest. Biopesticide can be an effective, environmentally sound method of managing pests. However, when using biopesticides in gardens, farms, homes, or interior-scapes, identify the pest and biopesticides, estimate the population of pests and biopesticides, purchase the correct biopesticide, release them correctly, and monitor their effectiveness.

**Factors affecting the Effectiveness of the Biopesticide:**

**Timing of Releases and Applications:**

Timing of biopesticide release is critical to the success of biological control. Since biopesticide work better as preventive rather than curative pest management method, it is important to release them when pest infestations are just beginning.

Some biopesticides are affected by the time of year, and can be less effective when applied untimely. The time of day can also be important, especially if the release is to be made outdoors or in a green house. When the temperature is high during the middle of the day, biopesticides tend to be more active and may disperse or leave the area they were released in. Higher temperatures during the release can cause increased mortality of the biopesticides, reducing the number of beneficial organisms. Other weather conditions, especially rain, may also have an impact on biopesticide survival during release. As a

general rule, releases should be made in a cool part of the day (early or late), under favorable weather conditions and at a time of year that the specific biopesticides finds suitable. Biopesticides purchased from a reliable and knowledgeable supplier has a better quality. However, there are some factors, such as shipping conditions that are out of the supplier's control. These factors must be taken care of with the help of the supplier.

**Environmental Conditions in Area of Release:**

Like all living organisms, biopesticides have specific requirements and limits for life. The conditions present in the area of release of biopesticides should be taken into consideration prior to making the release. For example, some species of predatory mites will do better under hot, dry conditions while still others will perform better under cooler high humidity conditions. Lighting can also have a dramatic impact on biopesticides. For example, the mealy bug destroyer beetle will slow or stop its reproduction, feeding and growth if supplemental lighting is not sufficient in winter months. If releasing a mobile stage of a natural enemy (e.g. adults that can fly), it may sometimes be advisable to cage the biopesticides on infested plants for a day or two to allow them to become accustomed to their new surroundings. The presence of pest insects will also encourage reproduction and reduce the likelihood that they will leave the area. In some cases, the presence of nectar-bearing plants or other food sources (e.g. aphid honeydew) may also encourage natural enemy populations.

Pesticide use may be the most important consideration when including biopesticides in a pest management program. Spraying for pests other than those being targeted by biopesticides releases may interfere with or eliminate the biopesticides. Care should be taken to avoid spraying materials harmful to biopesticides directly before, during and after release. If spraying must be conducted, it is important to find out which pesticides have the least effect on biopesticides.

## 4.2.5 Integrated Pest Management in Horticulture Nursery Management

The widespread introduction of high yielding cultivars and adoption of intensive crop management practices resulted in substantial increase in yields. Side by side it has also improved the conditions for insects, diseases, weeds, rodents and nematodes. Yield losses due to these pests range from 30-40%. Thus, the role of plant health coverage in agriculture production and sustainable productivity cannot be overlooked. Like any other technology, the concept of plant protection has also been changing with time, situation and understanding. To protect our environment, plant health coverage materials and methods should be eco-friendly and least hazardous. This has become more relevant in view of the gradual change in our outlook towards pesticides and other harmful toxic chemicals. Ornate, but slowly people have become more conscious of health and eco-system giving rebirth to organic farming. The concept of "Integrated Pest Management" originated basically to have a healthy approach to plant protection and reducing the use of hazardous and toxic chemicals.

Thus, I.P.M, is a "pest management system that in the context of the associated

environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible manner as possible and maintains the pest population at levels below those causing economic injury". An I.P.M. programme is an attempt to promote favorable ecological, economical and sociological outcomes which is accomplished by a best mix of the pest control tactics.

**What is I.P.M?**

I.P.M. is broad ecological pest control approach aiming at the best mix of all known pest control measures to keep the pest population below economic threshold level (ETL).

**Fundamental Components of IPM**

The use of appropriate scouting tactics, proper diagnosis of pest, action economic thresholds and conservation of naturally occurring bio-control agents (defenders/farmers friends) are fundamental components of a sound I.P.M. programme/strategy.

**How I.P.M?**

In crop production technology, I.P.M. is a schedule of practices which starts from field selection until harvest of a crop. The major components in this approach are cultural, mechanical, biological and chemical methods of insect pests, diseases, weeds and rodent control in a compatible manner.

**Aims of IPM**

IPM programme mainly aims to educate and encourage agricultural producers to grow crops using pest management methods like:

- Reduce, if not replace the use of synthetic organic pesticides
- That are environmentally sound
- Pose minimal risk to human health
- Enable growers to obtain a reasonable return on investment
- Ensure consumers a supply of high quality, safe and economical foods and other agriculturally related products.

**Concept (Principles) of IPM**

- Identification of the key pests to be managed
- Defining the management unit - the Agroecosystem
- Development of management strategy
- Establishment of economic thresholds
- Development of assessment techniques
- Evolving description or predictive pest models

**Interventionist IPM Tactics (IPM Tools)**

The IPM concept involves integration of cultural methods, mechanical methods, use of semiochemicals (attractants), use of natural products, conservation of biological agents, and application of need based chemicals.

The cultural methods which are recommended for adoption include resistant and tolerant cultivars; summer deep ploughing, clean cultivation and removal of crop residues and alternate host plants; appropriate sowing time; crop rotation and sequence cropping; optimum plant densities; inter cropping to promote population build up of parasites and predators; use of trap crops & barrier crops; avoidance of monoculture in large contiguous area and avoiding excessive irrigation and nitrogenous fertilization.

The mechanical methods include hand-picking of egg masses, collection of early instars of larva and grubs and their destruction to minimize the pest incidence. The removal and destruction of affected shoot terminals, affected plants from nursery could eliminate the hidden and hibernating pest stages.

The chemical controls mainly comprises of use of chemical insecticide and pheromones. It is simplest to state that the use of insecticides is only done when they may be necessary in the nursery, or just at planting out when they may be used as dips or soil granules on occasion to protect young plantations such as from root or stem-feeding insects such as termites, grasshoppers and weevils. The chemical treatment should only be done in extremely problematic and severe cases.

**Pheromone Trap for Monitoring the Pest Population**

Use of pheromones and light traps help in monitoring the build-up of pests and provide some reduction of phototropic adult stages through trapping. Pheromone are used extensively all over world for monitoring insect pest populations, but they have also had limited success in technique known as mating disruption or confusion. The timing of positioning sex pheromone traps 5 per acre area and the quality and timing of replacement of pheromone septa (every 15-21 days) at desired intervals is the key to success of such traps. Although sometimes a large number of adults get trapped, these are not to be seen as a control measure but are only indicative of pest activity (mating and egg laying) in the area, a signal to initiate the use of biocontrol agents and biopesticides.

Male moths attempting to locate the point-source attractiveness of female lose the ability to find mates, resulting in far fewer eggs laid and hence significantly reduced pest populations.

Biological control is the use of natural enemies of insect pests to regulate their numbers below a level where damage is economically important. It is a very useful strategy. More host-specific parasites (parasitoids) in the insect orders of Hymenoptera and Diptera can reduce the densities of pests considerably.

The biocontrol insects and biopesticides (fungal and bacterial based) are important tools to break/interrupt the continuous presence and activity of the pests present in the nursery. These normally act on the young stages of the pests (nymphal /larval /grub) and minimize the damage. The friendly biocontrol insects are natural parasites and predator. *Trichogramma species* are egg parasites while *Bracon, Encarsia* and *Apanteles* are larval parasites and *Coccygominus* is a pupal parasite. The predating insects voraciously feed upon the eggs, larvae and adults of various pests. Larvae of Chrysoperla and the adults of *Coccinella, Chrysopa, Cryptolaemus, Amblyseus* and spiders eliminate aphids, jassids, whiteflies, mites and Helicoverpa larvae through predation.

Microbial biopesticides are based on the organism, by-product produced by the organism or a mixture of organisms which are applied periodically to control nursery seedling pests. The most commonly used microbial pesticides are based on *Bacillus thurigiensis* (Bt). 'Bt' acts mostly on caterpillars and other insects, generally polyphagous and resistant to traditional chemical pesticides such as, Helicoverpa, *Spodoptera*, bollworms, hairy caterpillars and *Plutella*. Some Bt strains are active even on beetles and flies.

Baculoviruses, including Nuclear Polyhedrosis Virus (NPV) and Granulosis Virus (GV) are also important biopesticides which are highly host specific. The NPVs and GVs act through oral infection and multiplication of virus particles in infected cells in the gut and septicemia leading to death in 5-20 days. Normally the death of larva due to Bt/NPV/GV results in depletion of pupa and adults. The surviving pupa/adults are often deformed, infected and incapacitated to carry out normal lifecycles.

Fungal biopesticides based on *Beauveria* are highly effective on lepidopterans, whiteflies, hoppers, borers and also aphids and red spider mites. *Verticillium* is most effective on aphids, jassids & whiteflies. *Entomophtorales* are effective against whiteflies and *Metarhizium* on white grubs and locusts. These fungi mostly act on the pests through enzymes and toxins. Fungal agents like *Trichoderma* are highly potential seed treatment agents to control wilts and rots etc.

The botanical pesticides based on extracts of leaves, kernels or seeds of neem, karanja, chillies, garlic are equally efficacious insecticides. Neem is the most promising and widely used against a number of insect pests due to its versatile mode of action. It has a broad spectrum action on insects and is very useful. However, the problems of quality, shelf life, presence of aflatoxins and phytotoxicity limit its efficacy and eco-safety. Formulations based on sound technology would have a promising future.

**Note:** Chemical industries play a very important role in supplying various chemicals

in the form of fertilizers, insecticides, fungicides, weedicides, etc.

The newly introduced chemicals are often found to replace the older ones. Some chemicals impart hazardous effects on humans, animals, plants and environment. Therefore care should be taken to select the appropriate chemicals for use.

Restricted or Banned chemicals in the form of fertilizers, weedicides, pesticides, fungicides, acaricides, bactericides, etc should be avoided. The State Agriculture Department, Central Department, State Agriculture Universities should be consulted from time to time for the updated status in this regards.

## 4.3 Glossary

**Bacteria**: Prokaryotic microorganisms, which are involved in decomposition.

**Bio-pesticide**: The term biopesticide is used for the microbial preparation or biological pest control agents that are applied in a similar manner to chemical pesticides.

**Caterpillar:** Caterpillars are the larval form of a member of the order Lepidoptera.

**Coleoptera**: The order of insects comprising the beetles.

**Crop Rotation:** Crop rotation is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons for various benefits such as to avoid the buildup of pathogens and pests which occurswhen one species is continuously cropped.

**Diptera**: The order of insects comprising the flies.

**Disease:** A disease is an abnormal condition affecting the body of an organism.

**Fungi**: A fungus is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds as well as the more familiar mushrooms.

**Fungicide** Fungicides are chemical compounds or biological organisms used to kill or inhibit fungi and fungal spores.

**Mycoplasm:** Mycoplasma is a genus of bacteria that lack a cell wall. Without a cell wall, they are unaffected by many common antibiotics such as penicillin or other betalactam antibiotics that target cell wall synthesis.

**Nematode:** The nematodes are the most diverse phylum of pseudocoelomates and one of the most diverse of all animals.

**Parasite:** A parasite is an organism that lives on or inside another organism to the detriment of the host organism.

**Pathogen:** A pathogen or infectious agent is a microbe or microorganism such as a virus, bacterium, prion, or fungus that causes disease in its plant host.

**Pesticide:** A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest.

**Predator**: An organism which consumes live organisms as its source of food.

**Trap crop:** A trap crop is a plant that attracts agricultural pests, usually insects, away from nearby crops.

**Variety:** A variety is a plant or group of plants selected for desirable characteristics that can be maintained by propagation.

**Vector:** An insect or mite that transmits viruses.

**Viruses:** A virus is a small infectious agent that can replicate only inside the living cells of organisms.

**Weedicide:** Herbicide is commonly known as a weed-killer, is a type of pesticide used to kill unwanted plants.

## 4.4 Point to Remember

- Important methods of pest control are cultural method, physical method, mechanical method, legal or regulatory method, resistant varieties, biological method, and use of botanicals, chemical control, etc.
- Application of pesticides must be done at appropriate time, with appropriate rate and by using appropriate equipments.
- Chemical treatments of seed may be effective in controlling plant pathogens in, on, and around planted seed.
- Biopesticides are classified into viral biopesticides, bacterial biopesticides, fungal biopesticides, etc.
- Environmental conditions such as temperature, rainfall, and wind can affect the quality and undesired effects of pesticides applications.
- I.P.M. is broad ecological pest control approach aiming at the best mix of all known pest control measures to keep the pest population below economic threshold level.

## 4.5 Self Check Questions

1. Define the term pests and describe the major groups of pests.
2. Define disease and enlist the favorable conditions for disease infection in nursery.
3. What are the major characteristics of weed? Describe the Integrated Weed Management in nursery?
4. Describe the advantages and disadvantages of bio-pesticide.

## 4.6 Do It Yourself

- Visit any horticulture nursery in your area, observe, identify and list out the pest, disease and weeds on nursery plant.
- Visit an Agro Service Center in your area and list out the pesticide, insecticide, fungicide, biopesticide and herbicide along with their target pest, disease or weed.
- Visit a Biopesticide Production Unit and take information about its working and the organism or the active ingredient used in the biopesticide preparation.

# Unit 5: Management Practices in Horticulture Nursery

***Index***



## 5.1 Introduction

A horticulture nursery is a place, where seedlings, saplings, trees, shrubs and other plant materials are grown and maintained until they are planted in permanent places or sold. Raising the plant and maintaining it in a good condition is a very difficult task requiring timely monitoring of the plant. Raising seedlings and maintaining the young plants in a nursery is a continuous process. One must have complete information and know how about sanitation and cleanliness in the nursery, proper drainage of excess water, training and pruning of plants during its growth in the nursery. Filling of the pots and transfer of plants to another pot or bag with due care, utilization of mulching material to minimize the water requirement, application of plant growth regulators for propagation of plants, proper handling, packing and transport practices of nursery plants and effective selling of plants by providing customer care services are all the important aspects in the management of a nursery. It is utterly necessary to perform all these processes with proper care and in a well planned manner so as to obtain maximum profits from a Horticultural Nursery.

With the growing cities and rapid development in the nation, aesthetics and beautification is gaining importance. The horticulture nursery management has now gained a status of commercial venture. Retailer nurseries sell planting materials to the general public. Wholesale nurseries sell to other nurseries and commercial landscape gardeners. Private nurseries cater to the needs of institutions or private estates.

**At the end of this unit, you will be able to know and understand:**

- The practices of sanitation, drainage, training and pruning in horticulture nursery.
- Process of potting, repotting and mulching in nursery.
- Application of plant growth regulators in horticulture nursery.
- Packing, transport and customer services in nursery plants.

## 5.2 Contents

### 5.2.1 Sanitation, Drainage, Training and Pruning in Nursery

**(A) Sanitation :**

Sanitation is defined as "the formulation and application of measures designed to protect plant health". Maintenance of sanitation is necessary in any plant propagation work. If all the necessary sanitary precautions are taken at the onset, the problems would be less in magnitude and its management can be done effectively. It is necessary to use clean growing media, sterile containers, a sanitized bench and pathogen free planting materials in all plant propagation processes. However, soil borne pathogens may contaminate the soil mixture and media even when all precautions are taken. Small outbreaks of diseases can be controlled by using appropriate fungicides.

Sanitation practices in nursery include,

1. Prevention of insects, pests and diseases
2. Inspection for insect, pest and disease incidences
3. Environmental control leading to protection from harmful environment factors like hot sun, freezing temperatures, storms, etc.
4. Eradication of pests, diseases and weeds.

**Sanitation Treatments**

1. Sterilization of the propagation media, tools, and implements used is necessary in nursery plant production. Propagating media and tools can be easily sterilized by heat or by chemicals. A temperature of about 71 $^{0}$C for 30 minutes is considered sufficient to kill almost all disease producing pathogens.
2. Chemicals used for sterilizations are Chloropicrin, Formaldehyde, Methyl Bromide, etc.
3. Fumigation with chemicals is useful for destroying harmful bacteria, fungi and nematodes in a relatively small quantity of soil that is used for propagation of plants.
4. Drenching the medium with certain fungicides is also useful in eliminating pathogens from the soil, coco peat and other media.
5. General cleanliness of nursery area (inside and outside) and all the implements are necessary.

**(B) Drainage**

Drainage means the process of removing excess water from the soil using artificial means so as to enhance crop production. In order to facilitate healthy and sufficient vegetative and reproductive growth of plants, a good drainage system must be developed in the beds and around the nursery. Adequately gentle slope in the pot and bed surface is also desirable. It is extremely important to ensure that water logging does not occur in and around the pots and beds.

Soil needs artificial drainage for various reasons, when there is a high water table in the bed and when excess surface water cannot move downward through the soil.

**Advantages of Drainage**

1. The bed will not get waterlogged and plants can obtain essential amount of water as well as air
2. After heavy rains with effective drainage the soil comes in tilth faster to carryout agriculture operations in time.
3. The structure of soil improves. There is good aeration and warmth in the root zone which are essential for good root growth.
4. Soil micro flora that change organic matter into plant food and provides aeration and warmth in the soil.
5. Desirable chemical reactions take place and nutrients become available to the plants.
6. There is proper root development and accelerated nutrients absorption.
7. Seeds germinate faster and better stand of crop is obtained.
8. Due to healthy growth of plants they can resist the attack of pests and diseases better.
9. Healthy plants compete with weeds better.
10. Good drainage permits the removal of many toxic salts and thus, reduces damage to crops.

**Type of Drainage**

Drainage is of two types

a) Surface drainage and
b) Sub surface drainage or underground drainage.

**(a) Surface Drainage**

Surface drainage consist of open ditches that are laid out by eye judgment, leading from one wet spot to another and finally into an open area. This is often called natural system of drainage.

**Open ditches**: The pattern of ditches is regular. The method is adopted to land that has uniform slope.

**Field ditches:** Field ditches for surface drainage may be either narrow with nearly vertical sides or V shaped with flat side slopes. V shaped ditches have the advantages of being easier to cross with large machinery.

**Narrow ditches:** Narrow ditches are most common where large farm machinery is not used.

**(b) Sub-Surface Drainage**:

A sub surface or underground drainage will remove excess soil water. It percolates in to themselves, just like open drains. These underground drains afford the great advantages that the surface of the field is not cut off, no wastage of land and do not interfere with farm operations. On the other hand, they are costly to design the layout and not effective in slowly permeable clay soils. Types of underground drain are, tile or pipe drain, box drains, rubble drains, mole drains and use of pumps for drainage.

**Draining excess water from field through underground drain pipes.**

**(C) Training and Pruning in Nursery**

Training and pruning are two inter-related operations required in the nursery and field. Training is primarily done to give proper shape to the plants, while pruning is mainly concerned with the productivity or vitality of the plants. Both these practices involves the judicious removal of the undesirable plant parts like branches, limbs, twigs, flowers, shoots or roots etc.

**Training**

Training may include operations leading to staking or supporting to a nursery plants and it also primarily done to give proper shape to the nursery grown plants.

Training is primarily carried out in plants to provide the plant a mechanically strong framework, to expose maximum leaves to light for the photosynthetic process, for easy detection of diseases and pests and facilitate pest management and to ensure full sanitation by the removal of diseased parts or twigs and proper application of pesticides for elimination of the pest and disease.

**Pruning**

Pruning is an operation for the removal of live or dead branches and pest and disease infested branches from nursery plants to check spread of pest and disease in nursery

plants. Pruning is primarily done in nursery plants to promote and maintain healthy plant growth, through the removal of diseased or insect infested plant parts, dead branches or excess branches, to improve marketable quality of nursery stock, through the promotion of uniform shape, clean and even growth and to make plants more compact for display and transport.

**Care to be taken During Training and Pruning**

- Ensure that cuts are sharp and clean and care is taken to prevent main branch breakage and tearing.
- Prevent contamination of healthy tissues when pruning out diseased tissues through proper cleaning of tools between successive cuts.
- While pruning out diseased branches, cut beyond the diseased tissues. Many diseases grow internally, as well as externally.
- Application of Bordeaux paste on cuts and wounds is a beneficial practice.

## 5.2.2 Potting, Re-Potting, Depotting and Mulching in Nursery

### A. Potting

When a plant is transferred from a seed bed or a flat bed to pot, this operation is called as potting.

Potting of Nursery Plants is done for, preparing plants for sale such as rooted cuttings of grapes, growing plants for decoration like crotons, growing plants for experimental studies like pot -culture studies, for using plants as rootstocks in certain grafting methods like grafting of mango seedling.

**Potting Procedure**

1. Wet the seedbed before lifting plants. Lift the plant with a ball of earth intact with the root system. Do not pullout seedlings in the hot sun or when the soil around the roots is dry.
2. Fill up pots by putting some crocks first, then a layer of sand (5-8 cm thick) and finally pot mixture (8-10 cm thick).
3. Place the plant with the ball of earth in the centre upon the layer of pot mixture (Place on one side of pots in the case the root stock plant is to be used in grafting/inarching)
4. Put pot mixture around the ball of earth, press as you fill up and level off.
5. Leave 2 to 3 cm head space at top. Do not press over the ball of earth. It will break and damage the roots and set the stem of plant at the same height as it was in the seed bed.
6. Immerse pot with plant in a tub of water gently and keep inside water till air bubbles cease to come out. Remove and place the pot in shade.

**Potting of a Young Seedling**

**B. Re-potting**

Repotting is the process of transfer of plants from one pot to another pot.

**Repotting Procedure**

1. It is better to wet the potted plant 24 hours earlier to facilitate repotting (easy removal of plant from the pot).
2. The technique to remove the plant with a ball, intact is to keep the right hand palm over the soil, allowing the stem of the plant in between first two fingers and turn the pot upside down holding the pot at the bottom with the left hand and gently knocking the rim of the pot on the edge of table or any other hard surface or even on the bottom edge of another inverted pot. The ball of earth comes out of the pot. If for any reason, it fails to come out, break the pot knocking the sides with a stone or fork and free the soil from the pot.
3. Examine the roots, cut neatly with a secateur, the decayed, dead and dried or twisted roots. Reduce the size of the ball of earth around the roots.
4. Place the plant in the new pot at the same height at which it was in the old pot. Fill up pot with fresh pot mixture and immerse in water.

**Repotting of an Ornamental Plant**

**C. De-Potting**

Removal of nursery plant from the pot is known as de-potting.

**De-potting Procedure**

1. Loosen the soil around rim. Invert the soil. Keep the right hand palm under the surface of the soil with the plant stem between the two middle fingers.
2. Tap the rim sharply but gently against a hard surface or wooden object and take the plant out along with the root ball.
3. Safely loosen the excess soil between the roots and shake out the excess soil. Removed the decayed and dead roots with sharp secateurs.
4. Keep the plant with ball of earth in position in the new pot and then fill the remaining pot with new potting mixture till the top and level the surface.
5. Clip off few leaves to check transpiration. Then water thoroughly with a fine water spray. Keep the plant under partial shade for a few days.

**Depotting of Ornamental Plant Dieffenbachia**

**Care and Maintenance of Plant during Repotting**

- The initial reaction after potting and repotting is partial or temporary wilting. The transpiration loss has to be checked to help plants revive. Hence keep freshly potted plants under shade and "pot water daily".
- After about 6 to 10 days under shade, the plants should be gradually exposed to sun by keeping them for some hours under sun and then putting them under shade. The period of exposure can be increased every week until finally the plants can be kept in the open. This process is called "hardening".

**D. Mulching in Nursery**

Mulching is practice of covering soil surface with organic or inorganic materials to check the growth of weeds and loss of water through evaporation and regulate soil and media temperature.

**Mulching for Protection of Small Seeds**

**Mulching to Protect Delicate Fruits**

**Advantages of Mulching**

1. Seeds in the beds are irrigated frequently and can be washed away easily. Thus, placing of some mulch material prevents the blowing away of the seeds from the nursery bed.
2. Mulch also saves the seeds from being picked away by the birds and other stray animals, rodents, etc.
3. Covering of the nursery beds by any mulching material is equally useful to prevent the young seedlings from frost damage during winters and scorching sun during summers.
4. Mulching material also suppresses the growth of unwanted plants and weeds and also conserves moisture in the soil. It cools soil surface and stabilize soil temperature.
5. It adds organic matter to soil, if mulch materials are organic in nature and reduces soil erosion on sloppy lands.

**Mulching Material**

**(a) Organic Mulches**

Animal Manures**,** composts, composted municipal sludge**,** hulls, cobs, shells**,** sphagnum peat moss**,** pine needles, straw**,** wood products**,** shredded chip, or chunk bark**,** wood chips or shavings, waste wood, etc.

**(b) Inorganic Mulches**

Aluminum foil, black polyethylene, landscape fabrics, recycled rubber tires, stone, chips, pebbles and gravels.

**Organic Mulch: Wood Chips/Shavings**

**Inorganic Mulch: Polythene Sheet**

**Characteristics of Good Mulching Materials**

It should be easily and cheaply available. Material should not act as an alternate host for pest and disease. It should be easily degradable.

**Application of Mulching**

Mulching material in general should be placed over the beds immediately after sowing and removed after the seedlings have germinated and have attained sufficient height or when the danger of frost or high temperature is over.

## 5.2.3 Plant Growth Regulators (PGR) in Nursery

Plant growth regulators are the chemical compounds other than nutrients which are required in small or minute quantities to regulate modify or inhibit the plant physiological processes.

**Plant Hormones**

Plant growth hormones are the chemical compounds synthesized by the plant inside its body and transported from site of production to site of action to regulate, modify or inhibit the plant physiological processes

**Types/Groups/Classes of Plant Growth Regulators (PGR)**

1. **Gibberellins:** Play important role in cell elongation in plant cells e.g., Gibberellic Acid $GA_1$, $GA_3$, $GA_7$
2. **Auxines:** Play important role in cell division and cell multiplication. These substances are used mainly for the root initiation, e.g., Indol Acetic Acid (IAA), Indol Butaric Acid (IBA) and Naphathalic Acetic Acid (NAA).
3. **Cytokinins:** Play important role in cell elongation, e.g., Kinetin, Zeatin
4. **Abscisic Acid:** Growth retarding substance and plays an important role in fruit drop and thinning, e.g., ABA
5. **Ehtylene:** Mainly called as ripening hormone which hastens ripening in fruit crops. Ethrel also useful for sex expression in cucurbitaceous vegetable crops. Eg, Ethephon, Ethrel.

**Role of Plant Growth Regulators on Fruit Production**

**1. Propagation**

Large number of plants are propagated by stem cutting, leaf cutting and layering. For promoting rooting, the commonly used hormone is IBA followed by NAA. IBA enhances root formation on cuttings. Cytokinins also help in quick and profuse root formation on cutting and layers. By use of IBA, profuse root formation is observed in cutting at fig, pomegranate, croton, rose rootstock, hibiscus, grape etc.

**(A) Seed Germination**

Plant growth regulators are used to promote early seed germination and improve the germination percentage. Many seeds have natural dormancy which can be overcome by dipping the seeds in auxins.

- $GA_3$ @ 500 ppm solution enhances seed germination in aonla
- Guava seed- 1 % $KNO_3$
- Papaya seed- 20 ppm Sodium thisulphate 24 hour soaking
- Papaya seed- 20 ppm Thiourea 24 hour soaking
- Ber- 500 ppm GA
- 200 ppm GA + 5% Sucrose.
- Aonla seed, rayan seed- 500 ppm $GA_3$ 8 hrs soaking.

**(B) Vegetative Propagation**

**a. Cutting**: Auxins play an important role in the initiation of roots in cuttings.

- A concentration of 500-1000 ppm auxins are used by quick-dip method of treating cutting for species which are difficult to root.
- A concentration of 20-40 ppm auxins are used to the species which can be rooted easily.
- Guava cuttings: 5000 ppm IBA by quick dip method
- Grape cuttings:4000 ppm IBA by quick dip method
- Pomegranates: 2000 ppm IBA by quick dip method
- Litchi cuttings: 3000 ppm IBA by quick dip method
- Jamun cuttings: 5000 ppm IBA by quick dip method
- Fig cuttings: 1000 ppm IBA by quick dip method
- Air layering-guava: 3000 ppm IBA by pasting lanoline paste
- Air layering-pomegranate: 3000 ppm IBA by pasting lanoline paste
- Air layering-litchi: 5000 ppm IBA by pasting lanoline paste
- Air layering-jamun: 10000 ppm IBA by pasting lanoline paste
- Air layering-tamarind: 4000 ppm IBA by pasting lanoline paste
- Air layering-cashew: 500 ppm IBA by pasting lanoline paste

**b. Layering:** Paste of auxin pasted on the operated portion of the plant part helps in initiation of roots in grafting and layering eg Air layering in Guava

**Air Layering in Guava**

**c. Grafting:** IBA+6BA (500:500 ppm) in Bee wax paste is useful in joining the scion on stock in many fruit crops. Grapes, Mangoes, Sapota.

**d. Budding:** The treatment of IBA+6BA (500:500 ppm) in Bee wax paste is useful in bud joints in Citrus, Roses, Ber, Jamun, etc.

**e. Breaking Dormancy:** Gibberellins play an important role in breaking the dormancy of seeds of fruit crops by loosening the seed coat to permit water inside the embryo for germination, e.g., 500-700 ppm of $GA_3$ in Ber.

**f. Hastening Rootstock Growth**

- Rangpur lime seedlings: 200 ppm of $GA_3$ at one month interval.
- Jamberi rootstock seedlings: 200 ppm of $GA_3$ at one month interval.
- Aonla seedlings: 20 ppm 6-BA at one month interval.
- Khirni and Custard apple seeds: 1000 ppm $GA_3$, 20-24 hours seed soaking.

**Methods of Application**

The effectiveness of plant growth regulator is not only dependant on the concentration of substance, type of the plant species but also on the method of application. Different methods are used for the treatment of cuttings and layers with plant growth regulators.

**1. Prolonged Soaking Method**

In this method the basal end of cutting are dipped in the dilute solution (20 to 200 ppm) of the hormone for 24 hour in a cool dry place. After the treatment, the cuttings are planted in the nursery or in other suitable growing medium. The concentration of the hormone or growth regulator usually varies from 20 ppm to 200 ppm, depending on the plant species and type of the cuttings. The concentration is

usually low for easy rooting species and higher for difficult to root species. The nurserymen rarely use this method. However, it is very useful for difficult to root species, where some materials like vitamins, sugars and nitrogenous compounds are also used along with the growth regulators for facilitating rooting in such species.

**2. Quick Dip Method**

The method is an improved version of the previous methods. It is very effective method of treating cuttings with growth regulating chemicals. It is followed by most of the plant propagators for raising plants through cuttings. In this method, the basal ends of cutting are dipped in the concentrated solutions of a hormone for a short time, usually for 5 seconds to 2 minutes. The treated cuttings are then planted in the nursery or field for rooting. The concentration of hormone for quick dip method ranges between 500 ppm and 10,000 ppm, depending on the species and type of the cuttings. Usually a concentration of 4,000 to 5,000 ppm is used for the purpose. Higher concentrations may cause injury to the cuttings and thus should be avoided.

**Dipping of Cuttings in IBA Solution**

**3. Powder Dip Method**

In this method, the basal ends of freshly prepared cuttings are dipped in the carrier based hormonal powder for some time. After treating the cuttings, extra powder adhering to the cuttings should be removed by shaking. Cuttings are immediately inserted in the rooting medium. Seradix, a popular formulation is used by the nurserymen in this method. For effective rooting, the cut ends of the cuttings should be moistened before the treatment. At the same time, the excess of powder should be removed to avoid adverse effects on the rooting process.

**4. Spray Method**

Spraying of growth regulators is sometimes done to the mother plants before taking cuttings from them. Spraying of stock plants with CCC/Ethepon in concentration ranging from 500 ppm to 1000 ppm is sprayed 30 to 40 days before taking cuttings

from the trees. Cuttings taken from such plants, root better as compared to untreated plants.

**5. Lanoline Paste Method**

As described earlier, IBA is applied to the girdled portion of a layer or stool it is applied in lanoline paste for inducing rooting in plants. Honeybee wax may also be used in place of Lanoline.

**Preparation of PGR Solution**

**1. Plant Growth Regulator Powder**

For preparing hormonal powders, the required quantities of the hormone are weighed precisely on electronic balance and dissolved at the rate of 1 gm in 100 ml of acetone in a beaker. This material is poured into one kilogram of talc powder taken in mortar and mixed thoroughly with a glass rod. After mixing, the mixture is kept open in air for few hours. The alcohol evaporates. The dried talc is then ground to fine powder. This fine powder should be kept in airtight container and can be used for treating cuttings as and when required.

**2. PGR Solution**

For the preparation of hormonal solution, the required quantity of the hormone is measured and weighed accurately on electronic balance. It is then dissolved in a small quantity of acetone or alcohol. When the contents are fully dissolved, the final volume is made with distilled water. The pH of the solution should be nearly neutral. If the pH of the solution is higher or lower, it may not induce rooting; rather it would affect the rooting process adversely. The pH of the solution can be adjusted with the help of 0.1 N HCL or 0.1 N KOH. Citric acid, humic acid may also be used for lowering the pH of an alkaline solution. Hormonal solution should preferably be prepared fresh to avoid the solution becoming inactive. The cans of solution, however, can be stored in a cool, dry and dark place.

**3. PGR Pastes**

For preparing hormonal pastes, the required quantities of hormone are measured and weighed accurately and dissolved completely in small quantity of alcohol. The required quantity of the lanolin (greenish-yellow colored grease like substance) is also weighed and heated slightly in a beaker under gentle flame. When, the lanolin slightly liquefies, the dissolved hormone is poured in it. The contents are mixed thoroughly with constant stirring with a glass rod. The contents are then allowed to cool down. The paste is thus ready for use. Until use, the paste may be kept in a cool, dry and dry place.

**Precautions**

The use of root promoting hormone for the induction of rooting in the cuttings and layers has now become the backbone of the nurserymen. These are readily available in the market in various forms but it is always better to prepare them at nursery site itself. The hormones not only induce rooting but also help in growth and development of the roots. Indole butyric acid (IBA) and Naphthalene acetic acid (NAA) are most effective in cuttings and layers and these are used in tissue culture media also. To have better and

desired result from growth regulators, the following precautions should be taken for their preparation and further use;

- Check for expiry date of the hormonal powder.
- Hormones/growth regulators should be weighed and measured precisely and accurately, preferably with electronic balance, measuring jars and cylinders.
- As most of them don't dissolve in water, a proper solvent like acetone or alcohol etc. should be used.
- Purchase of required amounts PGRs as they are costly and difficult to store.
- Hormones are known to deteriorate faster in warmer temperatures. Therefore, they must be stored in cool and dry places preferably in a refrigerator.
- Solutions should always be made fresh. If required to store for some time, use of refrigerator is desirable.
- Use hormonal solution for treatment of cuttings and lanolin paste for layers.

## 5.2.4 Packing and Transport of Nursery Plants

**Packing:** It is defined as placing the nursery plants or propagating materials into a suitable container for maintaining their viability and vitality during storage and transport. Packing of nursery material is to be done from time to time. Emphasis should be given on packaging while transporting plants over a longer distance. To have a better price of the products, a nurseryman should pay high attention to the packing of the planting material.

**Advantages of Packing**

- Packaging protects the planting material from hazards caused during transport and prevents them from microbial and insect damage. It minimizes the physiological and biological changes taking in the planting material during transportation.
- Packing must maintain the natural condition of seedling of nursery plants and improve the shelf life of seedlings.
- Necessary information like name of seedling, name of nursery, age of seedling, etc. can be attached with packing boxes.

**Tomato Seedlings Ready for Transport**

**Materials Used for Packing**

| | |
|---|---|
| Hessian Cloth | : Made from the good quality jute fibers. |
| Sacking Cloth | : Made from the raw grade jute fibers. |
| Plastics | : Low & high density polyethylene, polypropylene, nylon. |
| Paddy and Wheat Straw | : For wrapping the earthen ball of the saplings |
| Sphagnum Moss | : For wrapping the earthen ball of the saplings |
| Dried Grass | : For wrapping the earthen ball of the saplings |
| Moistened Moss Grass | : For wrapping up the delicate planting material like vegetable and ornamental flower seedlings before packing. |
| Bottles or Tins | : For storage of clean seeds |
| Bamboo-Matted Boxes | : For storage of bulbs, tubers and corms |

**Characteristics of Ideal Packing Material**

- It should be cheap, easily available and highly suitable for the material to be packed.
- It should deliver the plants conveniently without affecting the quality and look attractive to the indenters.
- It should ensure protection against drying out and mechanical injury. It must be convenient and economical to handle.
- It should be well adapted to transport, loading with security and economy in volume and weight.

**Packaging Material: Seedling Tray**

**Care of Planting Material during Packing**

- Packing of seeds or plants or bulbs etc. should be done carefully so as to supply the planting material in safe and sound condition.
- During placing of the planting material into a package avoid bruising. Due care of grafted and budded plants should be taken to avoid the breakage of joint of the graft.

**Transportation of Nursery Plants**

The plants must be picked up the day they were received by the transport agency. These agencies do not have proper seedling storage facilities and the seedlings deteriorate

rapidly in these conditions. The interval between receiving the seedling from transport and planting them should be minimized, ideally 24 to 72 hours.

Seedlings must be transported in an enclosed vehicle. If there is no option to an open back vehicle the seedlings must be covered with a tarpaulin. This will keep seedling packages out of direct sun and protect them from drying in the wind. While transporting seedlings, never park the vehicle in the direct sun. Even in the boxes or bales seedlings can heat up to damaging temperatures in the sun. Do not throw or drop the boxes and bales. The seedlings can be damaged from bruising.

**Packaging for Transportation of Papaya Seedlings**

**Care of Plants**

After arrival of the plants from transportation, they must be kept in cool, shady place so that they lose the heat absorbed during the transit. The label indicating the variety, number of plants packed, etc must be confirmed. The leaves and roots must be kept moist by sprinkling water. Storage of the plants at field condition must be avoided.

## 5.2.5 Customer Services in Nursery Plants

The customers must be attended promptly,

- Ask for the requirement of the customer. Provide information regarding the requirement of the customer. Explain the advantages of the planting material being purchased.
- Show the planting material and explain the procedure for its plantation. Care should be taken that only authentic material is sold out from the nursery.
- Receipt should be given against purchase of the planting material. Rate of the planting materials should be fixed and displayed. Distribution of the planting material according to booking should be planned well in advance.

## 5.3 Glossary

**De-Potting:** Removal of plant from the pot is known as de-potting.

**Drainage :** Drainage means the process of removing excess water from the soil or bed or pot.

**Mulch :** Mulch is a layer of organic materials like bark, sphagnum peat moss, muck peat, compost, pine needles or inorganic materials like gravel, plastic, or any similar material uniformly spread on the surface of the soil under plants.

**Mulching :** Mulching is the practice of placing some mulch materials in the nursery beds mainly to regulate soil temperature, conserve moisture and suppress weed growth.

**Packing :** It is defined as placing the nursery plants or plant propagating materials into a suitable container for easy storage and transport.

**Plant Growth Regulators:** Plant growth regulators are the chemical compounds other than nutrients which are required in a small quantity to regulate, modify or inhibit the plant physiological processes.

**Plant Hormones:** Plant growth hormones are the chemical compounds synthesized by the plant inside its body and are transported from the site of production to site of action to regulate, modify or inhibit the plant physiological processes.

**Potting :** When a plant is transferred from seed bed or a flat bed to pot, this is called potting.

**Pruning :** Pruning is an operation for the removal of live or dead branches and pest and disease infested branches from nursery plants for the improvement the structure and health of the nursery plants.

**Re-potting:** The act of transfer of plants from one pot to another pot is called as repotting.

**Sanitation:** The formulation and application of measures designed to protect plant health.

**Training:** Training may include operations leading to staking or supporting to a nursery plants and it also primarily done to give proper shape to the nursery plants.

## 5.4 Points To Remember

1. Sanitation and drainage are the basic requirements in a horticulture nursery.
2. Training, Pruning, Potting, Repotting and Mulching are the regular operations to be carried out in any horticulture nursery.
3. Plant Growth Regulators (PGR) are used in liquid, powder or paste form in plant propagation nurseries.

## 5.5 Self Check Questions

**Answer the following questions**

1. What is the importance of sanitation and drainage in plant propagation nursery?

2. Write the procedure of repotting of nursery plants.
3. What is the role of plant growth regulators in the propagation of plants?

## 5.6 Do It Yourself

1. Visit a plant propagation nursery and record your observations regarding sanitation, drainage, type of drainage, method of training and pruning.
2. Practice potting, repotting, and depotting in nursery plants.
3. Prepare 100 ppm Giberillic Acid solution and use for dipping of seed for better germination.

# Unit 6: Mass Production of Nursery Plants-1

***Index***



## 6.1 Introduction

Nursery is a selected site having a well-defined boundary, where fruit, flower, vegetable or forest plant species and their cultivars are maintained and multiplied using various propagation techniques and methods. The importance of mass production of nursery plants is to distribute healthy, pest and disease-free plant material amongst the masses that have little knowledge about the techniques of raising plants. To multiply and introduce exotic species. Some important nursery species do not seed every year. These species can only be raised by collecting seeds in the seeding year. These seeds are then sown in the subsequent years. Mass production of nursery plants is the surest method of artificial regeneration on poor and barren sites. Nursery grown fruit, vegetable, flower and forestry plants can be a replaced in case of casualties.

**At the end of this unit, you will be able to know and understand:**

- The criteria for selection of nursery site and the various nursery operations essential in nursery management.
- Different types of plant propagation structures and other important inputs used in nursery management.
- Importance and benefits of hardening of nursery plants and the quality parameters used for selection of nursery plant.

## 6.2 Content

### 6.2.1 Mass Scale Nursery Plant Production

**Selection of Site for the Nursery:** The selection of site for a nursery should be made after considerable care and thought, since nursery location has a great impact on its overall success. Following are the most important considerable factors for selection of the location and site for a nursery.

**A. Ecological Factors**

1. **Climate:** The location should have mild climate with a long growing season. The sites experiencing extremes in temperature especially with rapid climatic fluctuation or incidences of high wind velocity, hailstorm or ice storms should be avoided.
2. **Topography:** Land for nursery should be leveled for most efficient use. Areas prone to flooding or frost should be avoided. Low-lying areas should not be selected for nursery.
3. **Soil:** The soil should have a good structure and porosity. It should be deep, sandy Loam to clay Loam in texture with sufficient water holding capacity. It should not be rocky or gravelly. Sites with degraded top soil should be avoided. The optimum soil reaction for most woody species is 5 to 7.2. Sites having a soil pH more than 7.5 should be avoided because it is very difficult to lower the pH. However, acid soils can be corrected fairly easily with the addition of lime.
4. **Water:** An ideal nursery site should have good rainfall distribution all over the planting and growing season, with minimum rainfall during supply period. There should be a permanent water source close to or within the nursery. Irrigation water for young seedlings should not contain more than 200 ppm total dissolved solids.

**B. Competition:**

Competition is not a limitation for a nursery having a large market area. Moreover, nurserymen in the vicinity or far away often cooperate with each other on most of the issues like equipment, shipping of material and labour etc.

**C. Social Factors**:

Many social factors like population density, wealth, leisure, mode of life, ethnic background, type of zone (rural/urban), presence of schools, hospitals, places of worship, civic organizations and cultural centers are all very important for the success of a nursery venture. All these issues should be given due consideration before selection of a certain location for a nursery.

**D. Biological Factors:**

Biological factors like presence or occurrence of serious pests, diseases, nematodes, rodents or weeds should be investigated well in advance. Scientists/experts should be consulted before the selection of site for nursery.

**Important Considerations for Organization and Development of Nursery:**

**(A) General Considerations:** Best site in the nursery should be allocated to production area. Transport, receiving and storage facilities should be located close to the road. Enough space should be provided around, for restroom, parking and raised platform etc. Short-term intercrops should be planted between long term species.

**(B) Economic and Cultural Considerations:** Most efficient land use. Plant size for market: If small size of plants are demanded the spacing between plants is reduced and vice-versa. The spacing for the upright growing varieties should be relatively less and in case of spreading varieties the spacing should be sufficient so as to accommodate the canopy of the plant. Mechanized operations require wider spacing whereas manual operations need narrow space.

**Important Nursery Operation**

**A. Field/Bed Preparation and Eradication of Competing Vegetation:**

Preparation of field/beds includes eradication of competing vegetation, leveling and cultivation of soil. Deep ploughing the field twice helps to loosen the soil and kill weeds and other vegetation. The stones and roots found in the soil while ploughing should be removed as they obstruct the growth of seedlings. Burning of dry grass and shrubby material helps to reduce the insect and weed problem and the left over mineral rich ash improves the fertility of the seed beds.

**B. Layout of Beds and Leveling**

Rectangular beds are preferred to other shapes. The width of the seed bed should be kept such that weeding and hoeing can be accomplished without entering the seed bed. It should be 1.2 to 1.5 m. The length of the seed beds should be not more than 12.5 m. The types of seed beds used in a nursery are, Raised beds: The nursery beds are raised to about 10-15 cm above the ground level. These types of beds are used in high rainfall areas. Sunken beds: To avoid flow of water outside the beds in dry areas. Sunken beds which are usually 15 cm deeper than the normal ground level are made. Level beds: Level beds are made in normal rainfall areas.

**C. Mixing of Farm Yard Manure**

Farm yard manure (FYM) crushed into fine powder should be thoroughly mixed with the top soil of the bed before sowing the seeds or planting the other planting materials (cuttings, suckers, rhizomes etc.). If the soils are sandy, addition of clay/pond soil proves beneficial.

**D. Sowing**

Sowing is done with the best seed available, to obtain the maximum number of healthy and sturdy seedlings for transplanting or field planting.

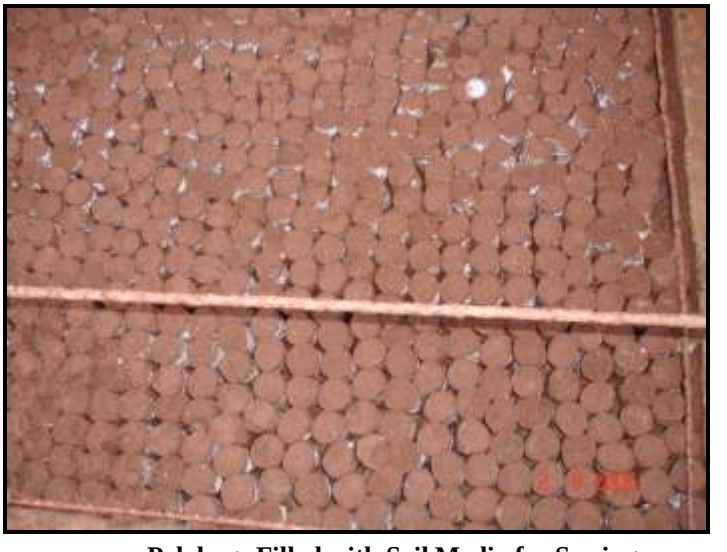
**Sowing on Beds:** Seeds should be sown in lines, so as to facilitate the interculture operations such as weeding, fertilization, etc. Shallow furrows of 0.5-1.0 cm depth should be made by fingers or using a stick, at a distance of 12-15 cm. Seeds should be

placed in furrows at an interval of 2 cm. After placing the seeds, the furrows should be covered with a thin layer of the soil and pressed so as to embed the seeds.

If seeds are very small, seeds are sprinkled on the top of the bed and the surface is compacted by pressing the top soil or mulched with straw to avoid the seeds from being flown away by water or picked by birds.

**Seedbed Mulching to protect seed from sun and water**

**Sowing in Polybags/Pots:** Polybags or pots are used for raising seedlings of number of species. They help to minimize the disturbance to the root system, avoid the problem of digging and are easy in transportation. Seeds planted in polybags or pots give a higher final survival. Generally polybags of 22.5 x 12.5 $cm^2$ size are used. Earthen pots generally 5 inch diameter are used for raising the rootstocks for the species which are multiplied by inarching. Polybag or pot filling mixture should contain thoroughly mixed well drained soil, FYM and clay or pond soil in 1: 1: 1 ratio. One to two seeds should be sown in each bag/pot at 0.5 to 1.0 cm depth. Gap filling in bags or pots should be carried out within two weeks of initial sowing.



**Polybags Filled with Soil Media for Sowing**

**Time of Sowing:** Time of sowing depends upon the time of seed ripening, the rate of growth of species and the size of the plant in demand etc. If the size of the plants to be planted out is small and the seed ripens in winter, sowing in spring can produce plants that are fit for planting. Budding, grafting etc. is done during rainy season.

| ***Sr. No.*** | ***Crop*** | ***Propagation Method*** | ***Season/Month*** |
|---|---|---|---|
| 1. | Mango | Stone Grafting | June- Aug |
| 2. | Mango | Softwood grafting | July-Sept |
| 3. | Mango | Approach Grafting | Sept- Feb |
| 4. | Mango | Veneer Grafting | Sept- Feb |
| 5. | Guava | Layering | July- oct |
| 6. | Pomegranate | Air layering | July- oct |
| 7. | Sapota | Soft wood grafting | July |
| 8. | Sapota | Approach grafting | Sept – Feb |
| 9. | Cashew nut | Softwood grafting | Round the Year |
| 10. | Citrus | Budding | Dec-Feb |
| 11. | Jasmine | Cutting | May-June |
| 12. | Aboli | Seed | June- July |
| 13. | Kanher | Cutting | June- July |
| 14. | Tagar | Cutting | July – Aug |
| 15. | Rose | Budding | Jan- Feb |
| 16. | Rose | Cutting | June/Sep-Oct |
| 17. | Chrysanthemum | Cutting | Oct–Nov, June–July |
| 18. | Carnation | Seed / Cutting | Oct–Nov, June–July |
| 19. | Gerbera | Seed / Sucker | June – July |
| 20. | Dahlia | Seed / Cutting | June, Oct – Nov |
| 21. | Zinnia | Seed | May-June |
| 22. | Aster | Seed | June – July |
| 23. | Marigold | Seed Kharif | June - July |
| 24. | Marigold | Seed Rabbi | Oct - Nov |
| 25. | Marigold | Seed Summer | Jan – Feb |
| 26. | Cabbage | Seed | Oct–Nov, July –Oct |
| 27. | Cauliflower | Seed | April – Dec |
| 28. | Khol-knol | Seed | Oct- Nov |
| 29. | Broccoli | Seed | Sept – Oct |
| 30. | Brussels sprout | Seed | Aug – September |
| 31. | Onion | Seed Kharif | May – June |
| 32. | Onion | Seed Rabbi | Sept- Oct |
| 33. | Onion | Seed (Rangada) Summer | Dec - Jan |
| 34. | Tomato | Seed Kharif | May- June/ Aug |
| 35. | Tomato | Seed Rabbi | September- Oct |

| *Sr. No.* | *Crop* | *Propagation Method* | *Season/Month* |
|---|---|---|---|
| 36. | Tomato | Seed Summer | May- June |
| 37. | Brinjal | Seed Kharif | June 2nd week |
| 38. | Brinjal | Seed Rabbi | Oct 1st week |
| 39. | Brinjal | Seed Summer | Jan 1st week |
| 40. | Chilli | Seed Kharif | may 3rd week – July |
| 41. | Chilli | Seed Rabbi | Oct |
| 42. | Chilli | Seed Summer | Jan – Feb |
| 43. | Capsicum | Seed | Oct - Nov |

**E. Pricking**

Pricking is the shifting of plants from one nursery bed to another or in the polybag/pot for better root and shoot growth. Pricking increases root growth and produces better and efficient root system in several species. While pricking, spacing is manipulated according to the requirement of the species at that particular growth stage. Pricking makes the plants hardier. Pricking can be done with a pointed slick or metal label.

**F. Irrigation**

Seed beds should be watered immediately after sowing. The polybags/pots can be irrigated with rose head can or polybags/pots should be kept in sunken beds about 25 to 30 cm deep so that flood irrigation can be adopted. Regular irrigations should be applied at an interval of 5 to 7 days during summer and 15 to 20 days during winter. Water should not be allowed to stagnate during rainy season. Light and frequent irrigations are preferred to heavy irrigations at long intervals.

**G. Weeding and Hoeing**

Weeding should be carried out regularly. Weeds should be destroyed early before they begin to compete for water and soil nutrients and before their growth makes hoeing difficult. Weeds should be eradicted before they flower so as to control their regeneration.

**H. Manures and Fertilizers**

Mixing of well-rotten Farm Yard Manure in the soil of the nursery helps to maintain its fertility. Nutrient status of the soil and the requirement of the species being grown should be assessed. Application of the nutrients and trace elements as per requirements should be made through soil placement or foliar spray.

**I. Lifting of Plants from Nursery**

Before removal from the nursery, plants should be thoroughly watered to loosen the soil and to avoid desiccation during transport until planting. Plants should be lifted carefully without any damage to roots, particularly the fine roots. Roots along with earth ball should be wrapped in grass or other material to prevent splitting of earth ball.

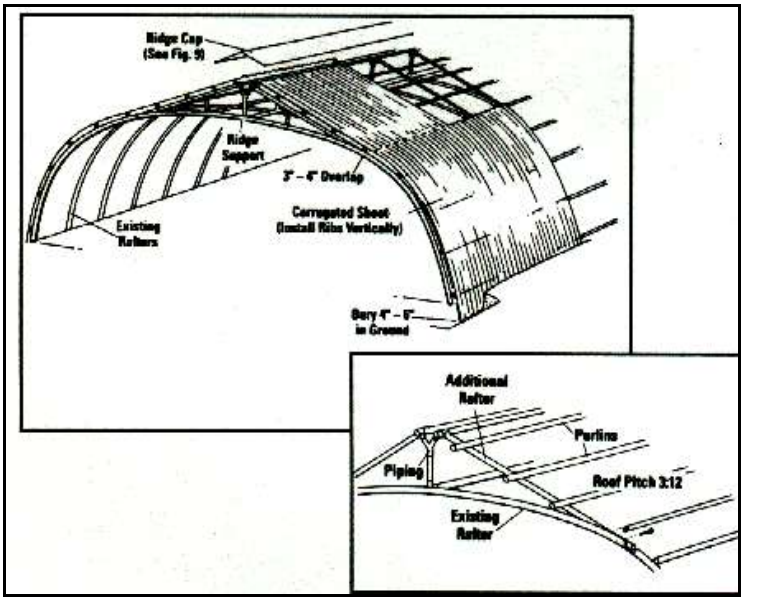
Plants after lifting from nursery and before planting in the field should be kept under shade and water should be sprinkled over them during transit. They should be transported to the destination as quickly as possible.

## 6.2.2 Plant Propagation Structures in Plant Nursery

The term Green House refers to a structure covered with a transperant material for the purpose of admitting natural light for plant growth. A greenhouse is a framed, inflated structure covered with a transparent material in which crops can be grown under at least partially controlled environment. A greenhouse is large enough to permit people to work within it and to carry out cultural operations.

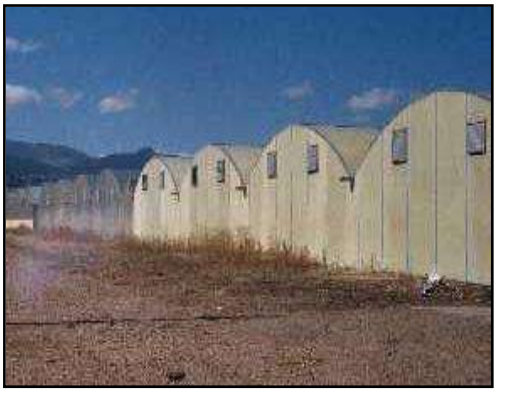
Various designs of greenhouse are constructed according to the need. They may be Quonset, Gutter Connected, Glass House, Plastic Film Greenhouses, Rigid Panel Greenhouses, and Greenhouse with Double-Layer Covering etc.

### Types of Greenhouse




**Quonset-Style Green House**

**Plastic film Green house**



**Gutter Connected Green House**

**Rigid Panel Green House**

**Shade Net House**

A shade net nursery usually has 20 m x 10 m dimensions. It is erected using GI pipes as a support. UV stabilized HDPE shade net of 50 per cent shade intensity is used to cover the nursery area at a height of 6.5 feet. Wire grid is provided at the top of the structure as support for shade net. To prevent insect entry, 40 mesh UV stabilized nylon insect proof net is fitted on all the four sides of the nursery. Provision is also made to pull polythene sheet over the pro-trays in the event of rainfall by way of making low tunnel structure. For preparing low tunnel structure, 3/4" LDPE pipes and 400 gauge UV stabilized polyethylene sheet are used.

**Seedlings grown in a Shade Net House**

**Plastic Film Greenhouse**

These greenhouses are covered with flexible plastic films (made up of polyethylene, polyster or polyvinyl chloride). Plastic covering of greenhouse is popular because it is cheap and the cost of heating is less as compared to glass greenhouses, but such films have short life. For example, the best quality ultraviolet (UV) stabilized film can only last for four years. Quonset design as well as gutter-connected design is suitable for using this covering material.

**Advantages of Plastic Film**

The time required to cover a green house structure using this covering material is minimum. It reduces costs of management and the use of equipment. The savings in fuel as well as the lower initial purchase price of the plastic film is also advantageous than glass greenhouse.

**Disadvantages of Plastic Film**

These covering materials are short-lived compared to glass and FRP. Though highest quality of plastic is ultraviolet (UV) light-resistant, 6 mm thick polyethylene films can last only for four years. The UV rays of the sun damage the plastic. It becomes brittle and darker. It tears very soon.

**Rigid Panel Greenhouses**

Polyvinyl chloride rigid panels, fiber glass-reinforced plastic, acrylic and polycarbonate rigid panels are used as the covering material in this type of greenhouses. These panels can also be used in the Quonset type frames or Ridge and Furrow type frames. This material is more resistant to breakage. The light intensity is uniform throughout the greenhouse when compared to glass or plastic. High grade panels have long life even up to 20 years. The main disadvantage is that these panels tend to collect dust as well as to harbor algae, which results in darkening of the panels and subsequent reduction in the light transmission. There is significant danger of fire hazard.

**Glass Greenhouses**

The average cost per year of a Glass house is more than that of plastic film greenhouses. Several styles of glass greenhouses are designed to meet specific needs. A Glass house is preferred when the greenhouse is to be placed against the side of an existing building. It makes best use of sunlight and minimizes the requirements for roof supports. An even-span greenhouse is one in which the two roof slopes are of equal pitch and width. Glass greenhouse is seldom used today because they are not adaptable to automation. Individual greenhouses standing free of one another are well adapted to cold climates since snow easily slides from their roofs. A ridge-and-furrow design refers to two or more green houses frames connected to one another along their length. The side wall is eliminated between greenhouses, which results in a structure with a single large interior. Consolidation of interior space reduces labor, lowers the cost of automation, improves personnel management, and reduces fuel consumption because there is less

exposed wall area through which heat can escape. Heating pipes are usually located beneath the gutters for this purpose.

**Quonset-style Greenhouse**

It is less expensive and can be purchased prefabricated or can be fabricated on the site. The trusses are constructed from water pipe that is bent to fit $180^0$ are modified for some-what more vertical sides. In a Quonset style greenhouse uses pipes which are 6 meter wide, 1.5 cm in diameter. One inch diameter pipe is used for a 30 foot wide greenhouse. Slightly larger pipe is driven into the ground into which the pipe arches are inserted for support. A 5 x 20 sq. cm wooden plant is attached to the base of the pipe arches such that it runs along the ground partially buried. This provides a basal point of attachment for the plastic film. The pipe arches or trusses are supported by pipe purling running the length of the house. Trusses are spaced 75 to 90 cm apart. The width of plastic film required to cover a Quonset greenhouse of given width can vary according to the height and shape of the trusses. A 6 meter wide greenhouse generally requires a 9 meter wide sheet of plastic. The covering width for a 30 foot wide Quonset greenhouse varies greatly; the more common width is 12 meter. These green houses are either constructed in a freestanding style or may be arranged in an interlocking ridge-and-furrow manner. In this latter case, the trusses overlap sufficiently to place a bed of plants between the overlapping portions of adjacent houses. A single large interior thus exists for a set of houses, an arrangement that is better adapted to the movement of labor and to automation.

**Gutter Connected Greenhouse**

This is the second currently popular plastic film greenhouse design. The gutters can be placed at greater heights than is possible in ridge and furrow Quonset ranges. Gutters, depending upon the manufacturer can range between 3 to 10 meter intervals. Columns can be placed in greenhouses with gutters spaced 12 feet apart and the columns placed under each, every other or every third gutter. Nine meter spacing between rows of columns though expensive, greatly enhances the ease with which the shading of plants with black cloth can be accomplished. Gutter connected greenhouses greatly minimize the exposed surface area and consequently the heating cost. Only 6 meter of plastic film is required to span a 5 meter bay. Gutter-connected bays of 3, 5, 7, 8, and 9 meter widths can be covered by plastic film sheets 4, 6, 8, 10 and 12 meter wide respectively. When additions are made, the plastic film can be removed from an existing side wall and the new houses connected at that point without any resulting discontinuity. In this way, a modest initial investment, inadaptable for automation, can be developed through expansions into a structure well suited to automation. The gutter-connected greenhouse brings us full circle to the category of permanent metal-frame greenhouses of which the glass greenhouse is a member.

**Greenhouse with Double-Layer Covering**

All plastic film greenhouses make use of the air-inflated system. Two layers of plastic film, one applied directly on top or the other from the outside, are held apart by a

cushion of air maintained at low positive pressure. Single sheets of plastic, wide enough to span the entire truss from ground to ground, are rolled out the length of the greenhouse and are attached to the greenhouse along its length at the ground level on both sides or Quonset greenhouses and in the gutters or gutter-connected greenhouses. The ends the sheet overlap the greenhouse ends by a few centimeters and it is attached at that point. The sheet is not attached to the trusses.

**Greenhouse Construction Related Aspects**

There are multifold considerations in selecting the site for the greenhouse. The geographical location may be chosen for its optimum climate favorable for plant growth or proximity to the market. Once the geographical location has been selected, the items to consider in addition to the above are topography of the land, transportation and present and future effects of adjacent properties.

**Location:** The first consideration in establishing a greenhouse is that of location. Several factors to be considered in this respect,

**Room for Expansion**: A land larger than the immediate needs should be acquired. The ultimate size of the range should be predicted. Area should then be added to this predicted figure to accommodate service buildings, storage and access drives. Doubling the area covered by greenhouses would constitute a bare minimum. Finally, extra space should be allotted to cover unforeseen needs. For instance, it may become necessary to engage in stockpiling of supplies as fostered by short ages of materials, or the future may call for holding ponds for water effluent from the range in order to reduce the nutrient content before releasing it into streams or the groundwater table.

The floor area of service buildings required for small firms is equal to about 13 percent of the greenhouse floor area. This requirement diminishes with increasing firm size to an area equal to 7.5 % of the growing area. On the average, service building are equal to 10 % of the growing area.

**Accessibility of the Site:** This is an important aspect for establishment of a greenhouse. If the proposed site is hilly, it should be anticipated that considerable land preparation will be required. Access roads to the property will need to be large enough and surfaced to handle large motor freight equipment. The type of neighboring properties may have varied effects on the greenhouse business. If it is an industrial area or becomes one-there could be damage to crops from some kinds of air pollution. The problems that might develop in the future are a matter of estimation. Greenhouses that were built outside of cities become surrounded by urban development with increased pressure of urbanization may develop problems in future.

**Available Water:** Water is one of the most frequently overlooked commodities in the establishment of a greenhouse business. Before a site selection, the available water source should be tested for quality and quantity. There are several cases where green house located in coastal and riverbed regions have been compelled to move to new locations to obtain water of suitable water quality. The cost of removing ions such as sodium, chloride, and bicarbonate is expensive but failure to do so result in plant injury. Water quantity is equally important since as much as 20 liters is used per square meter of growing area in a single application. Well water is the desired source since municipal

water is often too costly and may contain harmful fluoride. Pond or river water is subject to disease organisms and may require expensive chlorination.

**Orientation:** The greenhouse frame casts shadows. The magnitude of the shadows depends upon the angle of the sun and thus upon the season of the year. The latitude and altitude of the area should be considered while selecting the site because it affects light and shadows. It should be built with the ridge running east to west so that low angle of the winter sun can enter along a side rather than from an end where it would be blocked by the frame trusses. The ridge of single greenhouse should be oriented from north to south since the angle of the sun is much higher. Ridges and furrows greenhouses at latitudes should be oriented north to south in order to compensate for a shadow that occurs from north roof and gutter of each adjacent greenhouse. The north-south orientation permits this shadow to move across the floor during the day, whereas the east-west orientation does not.

**Economy of Construction**

Ridge and furrow type construction is usually more economical and needs less land area. Some disadvantages are excessive shade from the gutters, lack of temperature control of individual houses and no side ventilation. If forced air ventilation is used the problem of ventilators is nullified. The greenhouses should be arranged in such a manner so that labor is conserved and the crop can be handled more effectively. The greenhouses should be constructed in such a way that flowers can be cut and moved to the grading area and pot plants moved from area to area or to the shipping room very easily.

**Repair and Construction Equipment**

Owners of greenhouse businesses have to handle jobs like boiler repair and operation, painting, glazing, pipe fitting, carpentry, concrete work, gas engine maintenance, motor repair and routine maintenance of electrical and refrigeration equipment. The larger greenhouse operation will need to have one or more individuals who handle the engineering problems on the place.

**Atmospheric Environment of Greenhouse**

The atmosphere or environment in the green house affects the growth of plants. A study of the effect of the atmospheric environment upon the plant is a study of the response of the plant to its climatic surroundings. These factors with which the grower is directly concerned include the air temperature, the light intensity and duration, the carbon dioxide content of the air the relative humidity of the air, wind velocity and rainfall. Some of the factors may be partially controlled under some conditions, but usually the grower must alter his technique to fit the weather conditions. Any discussion of these climatic factors implies that they all interact and therefore each one must be considered in relation to all the others.

**Air Temperature:** The effect of air temperature upon plant growth must be considered under two interrelated categories- the day temperature and the night temperature. This distinction is well recognized by the commercial greenhouse grower. It is universal practice to operate a greenhouse with a differential between the range of air

temperature maintained during the day and the night. The difference in temperatures is usually 5 to $6^0$ Celsius.

Each kind of plant possesses a specific temperature range most suitable for its development. However, for greenhouse crops there is a general division of cool season crops and warm season crops.

Seed germination responds to air temperature. Some varieties of lettuce refuse to germinate properly when the air temperature reaches 25 to $30^0$ Celsius or above. Other seeds like okra, pea and lima beans, germinate, but are easily subject to rotting during the germination stages at these temperatures.

**Sunlight**: All plants require adequate light for growth but they often require shade to protect them from scorching. Most plants appear to require at least 1000 Footcandles of light to support growth. Higher levels improve growth up to 6000 to 10,000 Footcandles. Most vegetable and floral crops benefit by some shade.

Short days along with much cloudy weather in some areas cause light to be a limiting factor in greenhouse crop production during the winter, but in summer both the day length and the light intensity provide abundant light. In fact, excess light becomes a limiting factor in such cases. Coupled with high air temperature, high light intensities will adversely affect the growth of some plants; thus it is a common practice to whitewash the glass of greenhouses in the summer. Some outdoor crops are grown under tobacco cloth, cheesecloth or coarse muslin shade to obtain more satisfactory growth. A wooden lattice is installed for this purpose.

**Carbon Dioxide:** The atmosphere contains about 0.03 per cent carbon dioxide and is the source of this essential compound for plant growth. Usually carbon dioxide is not a limiting factor in crop production. Under conditions of bright sunlight the plant may be able to efficiently use greater concentration of carbon dioxide than normal atmospheric concentrations.

**Relative Humidity:** This factor plays an important part in the general vegetative responses of the plant and its susceptibility to diseases. Low relative humidity of the atmosphere is conducive to a hard type of growth, while high relative humidity causes a soft type, if all other cultural factors are similar. Also, the moisture content of the air directly affects the transpiration rate of the plant. Water losses from the plant are much higher when the relative humidity of the atmosphere is low.

The maintenance of adequate humidity conditions in the greenhouse is a major practical problem. Many techniques are used to raise the humidity. Walk ways and areas under raised benches are kept wet. Plants are often lightly sprinkled with a fine stream of water. In the winter steam injections appear to be feasible. This will influence both the air temperature and the moisture content. Light shade on the glass in the summer will also aid in raising the greenhouse humidity by lowering the air temperature.

**Wind:** Wind is not a direct factor in greenhouse crop production. Various fabrics tobacco cloth, cheesecloth and coarse muslin, are easily damaged by the strong wind. Sometimes it is necessary to use less desirable types of shade because of wind velocity. For best results, windbreaks should be constructed to reduce the velocity of the wind.

## 6.2.3 Input Management in Mass Plant Production

**Rooting Media**: The rooting medium is an important input for nursery production. The rooting media should have appropriate physical and chemical properties for better germination and root development. The media should be even in texture. It must be free from living organisms and pathogens. The media should be firm enough to hold planting material properly. Abundantly available rooting media are sand, coco peat, perlite, vermiculite, leaf mold, sphagnum moss, pumice, sawdust and wood shavings etc.

**Seeds**: Seeds are important factors influencing the yield potential. Seeds determine yield potential, adaptation to environmental conditions, and resistance to insect pests and disease. Seed selection is a critical management decisions in crop production. The cost of seed stocks usually is less than 5 to 10 percent of total production costs.

**Water Management:** Water is an important resource not only to nursery growers but to all humans. The leaching losses of soil nutrients can be reduced by controlling application of excess of water to the plants. Micro, overhead and pulse irrigation method are the methods of watering larger nursery area.

Micro-irrigation applies small amounts of water to the root zone area only. It also promotes compact root development which is important for subsequent tree survival in the landscape. Drip irrigation is often avoided in container production as drip lines cause difficulty in working around and moving containers. Drip or trickle system reduces the wastage of water by 60-70 per cent.

Overhead irrigation is designed to cover a large area. These are the cheapest irrigation systems. However, this system brings about uneven water distribution which slows down the plant growth. It encourages disease spread due to humidity. Wastage of water through runoff is more in this type of irrigation.

Pulse irrigation saves water in container production. Traditionally water was applied in containers by a system which wetted the rooting medium by a long but single application of water. Wastage and runoff was large in this type of application. In case of pulse irrigation, water is applied for about 15 minutes, four or more times with a pause of 30 to 60 minutes between each application. It reduces water wastage by about 30% and also minimizes runoff from containers. During the pause, water fills in the pores and also wets hard-to-wet components of the medium. The medium is saturated before excess water drains from the pots.

**Nutrient Management:** Nursery growers should test soils/media each year (mid-summer) to determine nutrient requirement of nursery beds for the following year. Usually in nursery beds normal fertilizers like urea, Diammnium Phosphate (DAP) and Muriate of Potash are applied. Fertilizers should be given in two spilt doses i.e. basal and top dressing (after 10 days). The application is done by broadcasting or foliar spray @ 0.5 to 2 per cent. Fertilization should be avoided just before transplanting. This causes diversion of plant energy toward root development and causes a negative impact on transplanted seedlings.

Common source of nutrients in nursery is FYM, compost, vermicompost, leaf mold, cakes etc. Besides, primary nutrients like nitrogen and phosphorus are essentially applied through straight fertilizers as these play an important role in root and shoot development.

**Type and Characters of Soil:** Soil maps are available from the Soil Conservation Service. Soil testing and a soil survey helps to determine soil quality and characteristics. It is the soil quality and characteristics which determine the layout of the nursery.

Soil characteristics for a good nursery soil are, easy tillage, well-drained soil with high water-holding capacity, land with less than a 5% slope to insure good aeration and surface drainage, fertile soils, high organic matter content (3-5%), without large stones, hardpans, or shale in the root zone.

Balled plants should be planted in a sandy-clay to clay-loam soil which will hold to the roots when the plant is being uprooted. Bare-root plants require light-textured soils that are sandy or sandy-loam in texture. These types of soils can be worked easily and will readily fall away from the roots as the plants are being harvested.

Container production does not require good soil on site. Container growing medium can be brought from remote locations. However, good soil on site as a resource in media construction may be useful. A firm surface which allows for the placing of containers and insures surface drainage is a must.

**Source and Quality of Water:** Seedlings contain over 95% water. The production calendar in tropical countries is determined by the rainy season, rather than by rising temperatures as in temperate regions. Proper irrigation and maintenance of high humidity in the propagation environment are prime responsibilities of nursery managers. Availability of ample amounts of good quality water is a very important factor in plant production. Potential sources of water include lakes and ponds, streams, wells, and municipal water supplies. Lakes, ponds and streams are the most inexpensive sources of water.

Criteria to be considered while determining the source of water are: Level of contaminants and debris, storage capacity to fulfill needs during the most demanding time periods (June-August), reliability of source, environmental and legal limitations which may be placed on natural water source.

Wells and municipal water sources have many limitations. It is expensive. There is quantity restriction on use. It has a higher pH.

It is very important to determine water source and water quality prior to purchasing land for nursery business. Water quality is a vital component and testing the water from source prior to nursery site selection is critical. The acceptable value of total soluble salts are between 175-525 ppm, with sodium levels between 20-40 per cent of the total salt (ideal level is less than 175 ppm salts and 35 ppm sodium). Good water quality is essential for healthy plant development. Saline water should be avoided unless salinity tolerant crops, such as Casuarina or Prosopis, are produced. Treating water with low concentrations of chlorine (1 ppm) helps to control water moulds.

Various irrigation systems have been developed locally. Gravity-fed systems are preferred by many small local nurseries in remote locations. However, for controlled irrigation a reliable water source supplying piped water year-round is absolutely necessary. Overhead sprinklers require a maximum of 10 acre feet of water for each acre of plants. Trickle irrigation systems are much more efficient than sprinklers. Drip irrigation is recommended in arid areas to reduce evaporative losses. High amounts of

calcium or magnesium can clog the nozzles and make frequent washing, or the addition of low concentrations of acid (for example vinegar), necessary. The necessary information about irrigation systems should be obtained from qualified suppliers. Watering should be done with a hose pipe that has a nozzle with fine holes so that young seedlings do not get damaged. The addition of a 60 cm metal rod to the hose makes targeted watering of containers easier and saves water.

In hot summer months the requirement of water may reach 3 inches per acre with sprinklers. Automated irrigation systems are usually more reliable and consume less water and labor than manual methods. The amounts and distribution of rainfall must be considered for determining the irrigation needs.

**Labor Requirements:** The number of employees you need in the nursery will depend on the size of your operation. Starting with fewer personnel gives more time for training and requires less financing. Mistakes will also be less likely and less costly with lesser personnel. The nursery business is inherently a seasonal activity with extended labor needs in specific time of the year. By diversifying the types of products (e.g., container-grown plants) and services (e.g., landscaping) offered, you can increase sales and reduce down-time of seasonal and part-time labor (e.g., migrant workers and students). It should be kept in mind that personnel planning include complying with Social Security, insurance, wage and hour, and income tax requirements for each of your employees.

**Light:** The right amount of light is critical for healthy plant development. Too much shade leads to etiolated and elongated growth of the seedlings which are weak and prone to fungal diseases. But too much light leads to sun scorching and drying out of the tender tissue. Quality shade cloth must be used to provide durable and uniform shade to the seedlings. Avoid using grass, reed or bamboo mats as they are not durable, do not provide uniform shade, and can harbor pests and diseases.

Shade cloth is usually woven from nylon (polypropylene) thread. But cheaper polyvinylchloride cloth called saran is also available. Saran shrinks about 3% and needs to be installed with slight sag. Shade cloth is available in from 30 to 95% shade. It is available in black, green or red colors. Colors change the wavelength of the transmitted light and thus influence plant development. Aluminium-covered thread is used to make cloth that reflects the infra-red wavelength from the sunlight and keeps the shaded area cooler. Shade cloth made from nylon can last over 10 years under tropical conditions.

Higher density shade cloths ranging from 60 to 80 per cent are used for young seedlings. Lower densities ranges between 30 to 40 per cent can be used for older ones. Note that three layers of 20% shade cloth do not necessarily provide a 60% shade, because they usually do not exactly overlap. Use a Par meter to ensure the correct amount of shade. The netting should be fixed above head height i.e. 2 m. The netting should run along the east and west sides to provide even shading and still allow easy access to seedlings. Additional layers of low shades may be installed at plant height if necessary. The netting should be supported on wooden beams or strong wires spread between poles at distances of 4–5 m or as convenient for the nursery. Wires are better than wooden beams because they drop less shade on the plants.

**Temperature:** The temperature range for optimal plant development is 25–35° C. Air temperatures above 40°C must be avoided. Additional heating needs to be provided to propagation beds where temperature drops below 20° C in winter. Heating cables or mats which provide bottom heat can easily be installed. Temperatures need to be most carefully monitored and held inside the recommended range during seed germination, rooting of cuttings and graft union formation.

**Gas Exchange:** Rooting, cuttings and germinating seedlings have high respiration rates. This means that oxygen is consumed and carbon dioxide released. The proper exchange of these gases is very important for good root development. In heavy soils and under waterlogged conditions, exchange of gases does not take place efficiently, resulting in accumulation of toxic amounts of $CO_2$ in the root zone. This condition hampers the healthy root growth.

Plants need to take up carbon dioxide for assimilation through the stomata on the leaves. Plants stressed by drought or nutrient deficiency have their stomata closed and cannot assimilate $CO_2$ properly. This results in retarded photosynthesis and growth. Atmospheric air contains about 0.03% $CO_2$ and 21% $O_2$. For specialized purposes, plants can be grown under elevated $CO_2$ levels of up to 3% to increase production.

In enclosed structures, the ambient level of $CO_2$ can drop till the assimilation through the stomatas is slowed down. Ventilating the structure briefly can avoid this.

**Electricity:** Electricity should be available in the nursery so that equipment such as ventilators, heating cables, electrical balances, and data loggers can be installed. If it is not possible to connect the nursery to the main power line, consider using nonconventional systems of electrification.

## 6.2.4 Production and Hardening in Plant Production

The hardening or acclimatization, process begins while the plantlets are still in vitro i.e. growing in the culture vessels. Acclimatization is the physiological adaptation of a plant or animal to changes in climate or environment such as light, temperature or altitude.

The tissue culture plants need acclimatization or hardening before they are transferred in the field. The acclimatization is necessary because there is vast variation in the environment of plants in vitro conditions and environment in the field. In culture vessels the *in vitro* plants are exposed to high humidity, hetrotrophic mode of nutrition, high ethylene concentration and constant temperature throughout the year. These conditions lead to the development of plants having low epicuticular wax, low stomatal density and stomatal malfunction, which make these plants more vulnerable to mortality in field conditions. To prevent this mortality, it is must to harden or acclimatize these tissue cultured plants.

**Approaches for Hardening of Plants:** To have success in hardening of tissue culture plants, the following approaches are adopted: plantlets to be hardened should have a balanced proportion of roots and shoots. Appropriate rooting media should be selected for establishment of plants *ex vitro*. They should be provided a balanced nutrition for survival of rooted plantlets. The rooting and acclimatization should be

simultaneous. The gelling agents from roots should be cleaned before the plants are transferred into the rooting media. Moisture content or humidity around transferred plantlets should be maintained for a better result.

**Advanced Approaches:** The conventional approaches are not sufficient to acclimatize the wide range of plant species, an alternative *in vitro* and *ex vitro* approaches can be adopted. Plantlets are pre hardened in culture vessels before being transferred into the soil. The plants can be hardened by bringing about alterations of sugar concentration in the culture medium. Some other means are like controlling the concentration of gelling agents, use of antitranspirants, control of gas exchange around the plantlets, use of growth retardants, and autotropic mode of nutrition of *in vitro* plantlets are also taken care of.

**Hardening Unit:** The hardening unit is provided with controlled light, temperature, relative humidity and periodic water spray system to harden (acclimatize) the nursery plantlets before transplanting. The nursery plantlets deflasked in the laboratory are kept in this hardening unit for 3 to 6 months for hardening before they are released into the field for cultivation.

**Hardening or Acclimatization:** The successful acclimatization of micropropagated plants and their subsequent transfer to the field is a crucial step for commercial exploitation of in vitro technology. However, the acclimatization of micropropagated roses was reported to be a difficult procedure because of rapid desiccation of plantlets or their susceptibility to diseases due to high humidity. The newly developed method of hardening, consist of cellulose plugs for support and protecting the roots during transfer to soil, and ventilated culture vessel to improve the resistance of the plantlets to desiccation. The plantlets thus grown showed better survival when transferred to ex vitro conditions.

In case of banana plantlets which are being acclimatized from cultured vessels to greenhouse, the plantlets have shoots and roots but are not yet capable of supporting themselves in the soil, prior to acclimatization,. The rooted shoots are about 6–8 cm tall and receive nutrients from an artificial medium that contains major nutrients. To help acclimatize the plantlets, the caps or tops of the culture vessels are removed for a period of at least several days. The recommendation is that a minimum of 10 days be allowed for in vitro acclimatization.

### Stages in Hardening

**Primary Hardening:** The micro cuttings were subjected to primary hardening in closed mini polytunnels with 95-100% Relative Humidity (RH) for 4-5week (stage II) and partially opened polytunnels with 65 % RH for 4-5 week (stage III).

**Secondary Hardening:** It is done under shade net with 45 % RH for 1 month (stage IV). The response of micro cuttings in various rooting media is recorded as budding, rooting and percentage survival.

**Shadenet House for Secondary Hardening**

**Assessment of Hardening:** The physiological status of plants during hardening was assessed at the following stages:

Stage I- Microshoots in the culture vessels (100 % RH).

Stage II- Microshoots on closed mini polytunnels (95- 100 % RH)

Stage III –Plantlets in partially opened polytunnels (65 % RH)

Stage IV – Plants under shade net (45 % RH)

**Standard Protocol for Hardening of Nursery Plants**

1. Prepare and sterilise substrate components (coconut fiber or coconut fiber-coal-pine bark). Place wet and sterilized substrate in germination tray cells.
2. From vitro plants kept in NEO medium for fourth months, select specimens with developed root systems. Then wash agar residues stuck to the roots.
3. Disinfect plants using Dithane M-45 (3 gm per 1 Liter of water). Transplant the vitro plant in each cell of the germination tray, burying part of the roots in the substrate and leaving the rest exposed. Provide water and place in the shade. Cover each tray with a plastic lid, preventing these from touching the leaves.
4. Apply daily misting with distilled and sterilized water. Water every eight days with half concentration MS solution for a month. Apply Benlate (0.70 g per Liter of water) in case of fungal infestation.
5. After three weeks, remove plastic lid for 4 hours a day for eight days; then remove the cover completely.
6. Transfer trays to a shady place for eight days and later to a site with 50 % direct sunlight.
7. From weeks 6 to 18 provide irrigation to the plants with tap water using an atomizer or sprayer.
8. Transplant each whole block of substrate to individual containers, filling them up with coconut fiber or a mixture of organic substrates plus icopor (polystyrene foam) and/or coal, to promote aeration and drainage.
9. Transfer plants to a shady, well-ventilated place, where relative humidity borders on 80 %.

10. Install a sprinkling system or provide water every 12 hours and avoid water logging or excessive humidity. Then transplant to environments similar to those where plantlets grows naturally.

**Care of Hardened Plants:** Extra care should be taken when young, rooted plantlets are being transferred from the culture vessels to the external environment. Tissue-cultured plantlets are delicate because they have been grown under low intensity artificial light and high humidity. The tissue cultured plants which are not adequately "hardened off" and may readily lose water when exposed to ambient conditions. When plantlets are removed from their containers, the artificial gel like agar medium is gently washed from the roots. This is important, because the agar contains sucrose and other nutrients that can serve as a medium for growth to the disease-causing organisms. The pre-hardened, tissue cultured plantlets with well branched roots are now ready for planting into potting media in a greenhouse nursery. The hardened-off plants should be quickly prepared for the greenhouse nursery.

## 6.2.5 Quality Standards in Nursery Plants

The specific quality standards of nursery plant for fruit, vegetable, flower and other plant are describe as below:

| Sr. No. | Crops | Propagation Method | Quality Standards |
|---|---|---|---|
| 1. | Mango | Grafting | 1 year old graft |
| 2. | Fig | Cutting | 8-12 month old seedling, 4-6 buds 30-40 cm height, 1-1.25 cm in diameter |
| | | Layering | 2.5-3 month old layering |
| 3. | Ber | Budding (Insitu) | 1 year old budding seedling |
| 4. | Custardapple | Seed | 5-6 month old seedling |
| | | Grafting | 1 year old graft |
| 5. | Aonla | Budding | 6-12 month old seeding |
| 6. | Banana | Sucker Tissue culture | 2-3 month old seedling |
| 7. | Grape | Cutting/Grafting (In Situ) | 15-20 cm long, 3-4 buds, 2.5 cm long stock. |
| 8. | Citrus | Grafting | 1-2 year old graft, 75-90 cm in height |
| 9. | Pomegranate | Air layering | 20-25 cm height, 6 month old seeding |
| 10. | Guava | Layering | 6-9 month old seedling |
| 11. | Cashewnut | Softwood grafting | 5-6 month old seedling |
| 12. | Papaya | Seed | 15-22.5 cm tall1.5-2 month old seedling |
| 13. | Coconut | Seed | 1-1.5 year old seedling, stem girth-10-12 cm, leaf stalk thick and short |
| 14. | Areca nut | Seed | 15-18 month old seedling |
| 15. | Tomato | Seed | 3-4 week old seedling, 12-15 cm height, 4-6 leaf stage |

| Sr. No. | Crops | Propagation Method | Quality Standards |
|---|---|---|---|
| 16. | Brinjal | Seed | 4-5 week old seedling, 12-15 cm old seedling, 6-8 leaf stage |
| 17. | Chilli | Seed | 6-7 week old seedling, 15-20 cm height |
| 18. | Cabbage/cauliflower | Seed | 3-5 week old seedling |
| 19. | Broccoli | Seed | 4-6 week old seedling |
| 20. | Onion | Seed | 6-8 week old seedling, 20-25 cm height |
| 21. | Lettuce | Seed | 4-5 week old seedling |
| 22. | Rose | Budding | 3-6 month old seedling |
| 23. | Jasmine | Cutting | 60-65 days old seedling |
| 24. | Aster | Seed | 35-40 days old seedling, 4-6 leaf stage |
| 25. | Marigold | Seed | 3-4 week old seedling, 5-6 leaf stage |
| 26. | Gaillardia | Seed | 3-4 week old seedling, 4-6 leaf stage |
| 27. | Zinnia | Seed | 5-6 leaf stage, 10-15 cm height |
| 28. | Aboli | Seed | 4-5 leaf stage |
| 29. | Dalia | Seed | 3-4 week old seedling |
| 30. | Carnation | Seed | 20 days old seedling |
| | | Cutting | 2 month old seedling |
| 31. | Gerbera | Seed | 2 leaf stage, 5-6 week old |
| | | Sucker/Tissue Culture | 5-6 leaf stage |

**General Quality Standards for Nursery Plant**

- The graft union should be healthy and the size of scion and rootstock should be equal.
- Color of leaf, morphology of leaf should be in proper standard in according to variety and species.
- The nursery plant should be free from disease and pest and have a vigorous growth.
- The shoot and root development of nursery plant should be in proper ratio. The nursery plants should be free from weeds.

## 6.3 Glossary

**Bud union/Graft union:** A swollen area just above the soil level where one variety has been onto the rootstock of another variety. The bud union is not always swollen, and on some older plants it can be difficult to find. On young bare-root trees the bud union may look like a slight bend.

**Budding:** Means of vegetative propagation where the scion is reduced to a single bud which is inserted into a rootstock.

**Dormancy:** A state of suspended growth or the lack of outwardly visible activity caused by environmental or internal factors in a seed or bud.

**Grafting:** The process of inserting a part of one plant into or onto another in a way that the two will unite and continue growth as a single plant.

**Hardening:** Treating plants to make them more resistant to adverse environmental conditions, usually by exposing them gradually to increased light, temperature changes, and drought.

**Plant propagation:** Increase in numbers or perpetuation of a species by reproduction.

**Seed:** A mature ovule. Contains the embryo, endosperm (only remnants in most dicots), and the seed coat.

## 6.4 Point To Remember

- Nursery is a selected site where plants are multiplied on a large scale.
- Proper tillage operations help to check weed and insect attack in a nursery.
- Seed should be sown at proper time and in proper container with good growing media.
- Location, water availability, orientation are the important points to be considered at the time of greenhouse construction.
- Temperatures, sunlight, CO2, relative humidity are the important environmental factors to be considered in greenhouse cultivation.
- The tissue culture plants need acclimatization or hardening before they are transferred in the field.
- The rooting media should have appropriate physical and chemical properties for better germination and root development.

## 6.5 Self Check Questions

- Define nursery and describe the factors necessary to be considered for the selection of site for nursery development.
- Enlist the various nursery operations and describe them in brief.
- What are the types of plant propagation structures used in a plant nursery?
- What is the protocol for hardening of nursery plants?

## 6.6 Do It Yourself

- Visit a nursery and collect information about site selection, input resources and quality standards of various nursery plants.
- Visit to plant propagation structures in nursery, measure the dimension of various structures like its height, width and calculate the area.
- Visit a tissue culture unit and collect information about the hardening process in nursery plants.

# Unit 7: Mass Production of Nursery Plants-2

***Index***



## 7.1 Introduction

At present, there is an increasing need to supply planting materials of fruit trees, vegetables and ornamentals. This is because it is very difficult for small and marginal farmers to procure or produce the same locally or raise them on their own farms. In order to meet present and future demand for planting material, there is a need to promote on farm and community nurseries. Such nurseries can be owned and managed by individual farmers, by self-help groups, by schools, by a range of other local institutions. They provide income generating opportunities, act as models for further nursery development, provide seedlings more cheaply to planters, and can raise the particular species that local people are interested in.

**At the end of this unit, you will be able to know and understand:**

- Demand and supply pattern of the nursery plants.
- Mass scale production of mango, guava, grape, banana, coconut fruit planting material.
- Mass scale production of vegetable seedlings in nursery.
- Mass scale production of flower crop seedlings like Chrysanthemum, Carnation, Rose, Gladiolus, Jasmine, etc.
- Branding and marketing of nursery plants and seedling.

## 7.2 Content

### 7.2.1 Demand and Supply Analysis of Nursery Plants

Demand and supply of the nursery plants is an economic model of price determination of the plants for sale. It concludes that in a competitive market, the unit price for a particular plant will vary until it settles at a point where the quantity demanded by consumers will equal the quantity supplied by producers, resulting in an economic equilibrium of price and quantity. The demand and supply of the plants are governed by the following laws,

1. If demand increases and supply remains unchanged it leads to higher equilibrium price and quantity.
2. If demand decreases and supply remains unchanged, it leads to lower equilibrium price and quantity.
3. If supply increases and demand remains unchanged, it leads to lower equilibrium price and higher quantity.
4. If supply decreases and demand remains unchanged, it leads to higher price and lower quantity.

The supply-demand model is a partial equilibrium model representing the determination of the price of a particular good and the quantity of that good. The supply demand model of the nursery plants are represented by the Supply Curve and the Demand Curve.

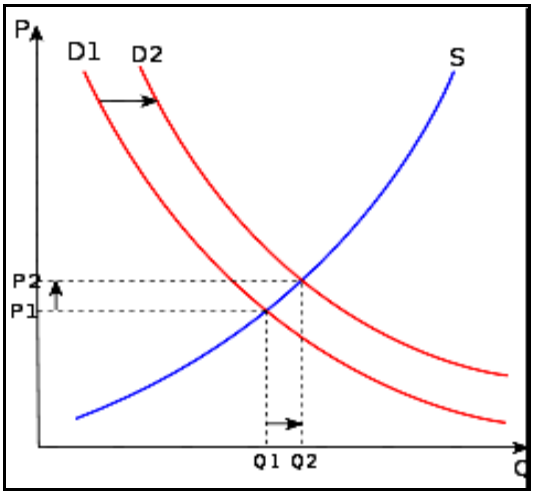
**The Supply Schedule is affected by the following factors:**

1. Production costs
2. The technology used in production
3. The price of related goods
4. Firm's expectations about future prices
5. Number of suppliers

**The demand is affected by the following factors:**

1. Income
2. Tastes and preferences
3. Prices of related goods and services
4. Buyer's expectations about future prices
5. Number of buyers

D1 is the demand of a certain nursery plant at a certain time. The demand for the plant increases to D2 and the consumers pay an increased price for the similar quantities. The supply curve depicts that increasing supply but reducing demand can lower the price of a certain commodity. While decreased supply during a steady demand can also increase the price of the products.




**P Axis: price of plant, Q Axis: Quantity available for sale. D: Demand. S: Supply.**

**Demand of seedling of fruit plantation and vegetable in India per year**

| *Crop* | *Annual seedling requirement (millions)* | *Annual seed requirement (Kgs)* |
|---|---|---|
| Tomato | 13028 | 600 |
| Brinjal | 200000 | 635 |
| Chilli | 14157 | 195 |
| Onion | 695000 | 2779 |
| Cabbage | 22963 | 101 |
| Cauliflower | 12669 | 87 |
| Mango | 10 | - |
| Banana | 3151 | - |
| Citrus | 14222.22 | - |
| Gauva | 20 | - |
| Grapes | 80 | - |
| Papaya | 576 | - |
| Pomegranate | 21 | - |
| Sapota | 1.6 | - |
| Coconut | 2.5 | - |
| Cashew nut | 31 | - |
| Arecanut | 1 | - |

## 7.2.2 Mass Scale Plant Production of Fruit Plants

Setting up of a fruit nursery is a long term venture and needs lot of planning and expertise. Mistakes committed initially on any aspect like selection of soil, raising of right kind of cultivars/varieties, plant protection measure, etc., reduce the financial returns greatly from the investment, in addition to wasting time and energy. So, careful planning is needed before setting up a nursery. The vegetative propagation of fruit crops makes them vulnerable

to transmission of several diseases and pests through the mother plant. Thus, importance of testing of material in the process of its preparation at various stages needs due attentions. The targets of the enhancing fruit production in the coming years will be achieved only through production and distribution of healthy, genuine and high quality planting material of commercial/improved varieties of fruit crops in sufficient quantities. Similarly, adequate measures are taken in the preparation of plant material to produce disease and pest free plant material.

**Progeny Trees/Mother Plants:**

A nurseryman should have progeny trees of all the promising cultivars of fruits that can be grown in that particular area.

**Criteria for Selection of Mother Plants:**

- The mother plants of the variety should be genetically true to type.
- The mother plants should be healthy and free from any diseases, pest infestations and physiological disorder.
- The mother plants should have known pedigree records regarding bearing potential, fruit quality and problems, if any.
- The mother plants should be a prolific and regular fruit bearer.

**Criteria for Selection of Rootstocks**

a) Dwarfing and semi-dwarfing in nature
b) Compatibility with the known commercial cultivars.
c) Resistance/tolerance to biotic (diseases and pests) and abiotic stresses.
d) Rootstock should have well developed and profuse root system.
e) The rootstock should be easy to propagate vegetatively or from seeds.

**Mango (*Mangifera indica* L.)**

**Raising of Rootstocks:** Mango seedlings grown from stones of seedling trees are used as rootstocks. Stones should be collected from vigorous, disease free and high yielding trees during the harvesting season. Mango stones lose their viability very soon on desiccation. Stones are sown during in June-July. When the seedlings attain the age of 2-3 months, they should be transplanted in well prepared beds or polybags. Plant is allowed to grow as a single stem for six to eight months. Scion is ready for grafting when the plant attains pencil thickness or a little more. Now a days, high density planting is getting popular for which dwarf trees are demanded. To produce dwarfing effect it is necessary to select the correct type of rootstock. The rootstock such as Villaikolamban, Ambalavi are recommended for this purpose. The locally found wild mango stones may also be used as rootstock for the same purpose.

**Methods of Propagation:** Nurserymen in many of the mango growing areas still use inarching, traditional method of propagation. During past few decades, experimental results have shown that veneer grafting technique can be used with high success rate in North India. Stone (epicotyl) grafting is suitable for Coastal regions. Now-a-days softwood grafting is being used commercially for mango propagation in several parts of south India. Veneer grafting and soft wood grafting techniques should be used for large scale multiplication of mango all over the mango producing area.

**Softwood Grafting:** The technique of softwood grafting is similar to that of cleft or wedge grafting. In this case, grafting is done on 3 month to 8 month old rootstocks. In south India, the rootstocks attain graftable thickness within 3-6 months due to mild winter. In the past, this technique was used for *in situ* orchard establishment under adverse soil and climatic conditions as the grafting operation is performed using cleft/wedge method on the newly grown top portion of the plant one year after the rootstock establishment in the field. The scion shoots of the thickness equal to that of rootstocks are defoliated 7-10 days prior to grafting. The graft should be secured firmly using 1.5 cm wide, 200 gauge polyethylene strip. July and August months with high humidity and moderate temperature are the best for the success of softwood grafting.

**Veneer Grafting:** This method of propagation holds promise for mass scale commercial propagation. The method is simple and can be adopted with success. Eight month to one year old seedling rootstocks are suitable for this method. For conducting this grafting operation, a downward and inward 3-4 cm long cut is made in the smooth area of the stock at a height of about 20 cm. At the base of cut, a small shorter cut is given to intersect the first cut so as to remove the piece of wood and bark. The scion stick is given a long slanting cut on one side and a small short cut on the other so as to match the cuts of the stock. The scion is inserted in the stock so that the cambium layers come on the longer side. The graft union is then tied with polythene strip as recommended for inarching. After the scion obtains nutrition from the stock and remains green for more than 10 days, the rootstock should be clipped in stages. The scion wood to be used for veneer grafting requires similar preparation. The desired shoots should be defoliated at least one week prior to grafting so that the dormant buds in the leaf axile become swollen.

**Scion Sticks ready for Grafting**

**Grafts tied and Secured with Polythene Strip**

**Stone Grafting (Epicotyl Grafting)**: Mango is generally propagated by inarching and veneer grafting in north India, these methods are time consuming. Stone grafting is a technique of faster multiplication of mango. This method is simple, economic and fast. Fresh mango stones are sown in the nursery beds. After germination, 10-15 day old seedlings with tender stems and coppery leaves are lifted along with the stones. The roots and stones are dipped into 0.1 per cent Carbendazim solution for 5 minutes after washing the soil. The seedling stems are headed back leaving 6-8 cm long stem. A 3-4.5 cm longitudinal cut is made into the middle portion of the cut stem. A wedge shaped cut starting on both sides is made on the lower part of scion stick. The scion stick should be 4-5 months old and 10-15 cm long containing plumpy terminal buds. The scion stick is then inserted in the cleft of the seedlings and tied with polythene strip. The grafts are planted in polyethylene bags containing potting mixture. The bags are kept in the shade for protection from heavy rains. When the scion sprouts and the leaves become green, the grafted plants should be planted in nursery beds. July is the most suitable month for stone grafting.

**Care of Nursery Plants**

The nursery beds should be covered with suitable material. The beds should be irrigated whenever there is danger of frost. The irrigation should be given at 4-5 day intervals depending upon the soil condition. A light application of Calcium Ammonium Nitrate or Ammonium sulphate is also recommended to encourage the growth of plants. The beds/polybags should be kept free from weeds by regular weeding.

**Various Stages in Stone Grafting of Mango**

**Guava (*Psidium guajava* L.)**

**Raising of Rootstocks**: Raising rootstocks in polyethylene bags is recommended as this gives better establishment of plants in the field on account of undisturbed tap root system. Guava seeds have a hard coating over the endocarp as a result of which usually long time is required for germination. Fresh seeds should be extracted from drupe fruits and washed thoroughly to remove the pulpy material clinging to the seeds. It should be treated with fungicide (0.03 % copper oxychloride) before sowing in the polyethylene bag to prevent damping-off of seedling. Seeds of guava are sown in polyethylene bags of 20x10 cm or 18x27 cm size during any time of the year. Polyethylene bags are filled with soil, sand and Farm Yard Manure in 3:1:1 ratio. All the polyethylene bags are covered with 100 micron (400 gauge) white polyethylene sheet soon after sowing of seed. During winter months, the polyethylene mulch conserves heat and create conducive environment (micro-climate) for rapid germination and early establishment of seedlings.

**Patch Budding**: Seedlings of about one-year-age, pencil thick, uniform and active in growth are selected. This method is most satisfactory when vigorously growing plants with 1.25-2.5 cm in stem diameter, are used as rootstock. The trees from which buds are taken should be highly vegetative with lush succulent growth to permit easy separation of buds from the stem. It is better to take swollen and dormant buds from leaf axil of mature twigs of the scion variety. A patch, approximately 1 cm to 1.5 cm with a bud seems to be taken for better success. Similarly, 1-1.5 cm long patch is removed from the rootstock and bud is fitted into the remaining portion on the stock seedling. Bud should be fitted at a height of nearly 15 cm above the ground level. Polyethylene strip is used for keeping the buds close to the stock. When the bark adheres

tightly to the wood, budding is usually successful. In successful cases, about one-third shoot of the rootstock can be removed for forcing the growth of buds. The remaining two-thirds can be removed after three weeks of the first cutting, leaving about 2-3 cm above the bud. The best time for budding is from May to August in different parts of the country.

**Stooling**: Stooling is the easiest and cheapest method of guava propagation. This method can be used for quick multiplication of desired varieties and also rootstocks. In this method, self-rooted plants (cuttings and layers) are planted 0.5m apart in the stooling bed. These are allowed to grow for about three years. Then these are cut down at the ground level in March. New shoots emerge on the beheaded stumps. A 30 cm wide ring of bark is removed from the base of each shoot rubbing the cambium of the exposed portion in May. All the shoots are mounted with the soil to a height of 30 cm. The soil is covered with mulch to conserve the moisture. After a period of two months of the onset of monsoon, the shoots are detached from the mother plant at ringed portion and planted in the nursery. The shoots are headed back to maintain the root and shoot balance before planting in the nursery by following the technique of ringing and mounding of the shoots, second time stooling is done on the same mother shoot in the first week of September. The rooted shoot layers are detached in the first week of November. Thus, stooling is done twice on the same mother stool in a year. The stooling of a mother stool can be done for many years. With the advancement of its age, the number of stool layers also increases every year. The growth and development of a stool layers are better than seedlings. The application of rooting hormone is not required.

**Air Layering**

**Propagation of Guavas by Air Layering**

Air layering is one of the most important commercial methods in practice for guava propagation. Rainy season (preferably July-August) is the most suitable period

for air layering. In this method, limbs of 1.2cm or more diameters are girdled by removing a strip of bark with a width of about 2cm. The girdled area is bound with a ball of moistened sphagnum moss of about 7 cm diameter and 10-13cm long, which is then wrapped with polyethylene film and tied loosely over the wrap to prevent bird damage and also to prevent the moistened moss from overheating. Roots usually start developing in three to five weeks. When they grow through the ball of moss, the stem may be detached from the mother plant below the girdled area. The polyethylene film is removed and the new plant is potted in manured soil in pot/polyethylene bags and kept in the shade until new leaves appear. When the new growth is about 15-20cm long, the plant is hardened in full sunlight before transplanting in the field.

**Saplings of Guava Ready for Sale in Nursery**

**Aonla (*Emblica officinalis)***

**Raising of Rootstocks**: Aonla is commercially propagated by budding or grafting on seedling rootstock. Fruits are collected from local aonla trees and used for rootstock raising. Mature fruits should be collected during January and February. Fruits are dried in open and seeds are extracted by applying light pressure. The timing for sowing of seed has been standardized. Seed are sown on raised bed (after soaking in water for 12 hours) or in poly bag during March-April facilitate quick germination. Germination of seeds of aonla is better during March-April and July-September.

**Patch Budding:** Six months to one-year old seedlings are used as rootstock for budding. The scion shoots should be selected from the mother plants, which are prolific bearers and free from disease and pest incidence. Patch or Modified Ring Budding during mid of May to September gives 60 to 90 per cent success under north Indian conditions. However, in south India, aonla propagation is being done almost 8-10 months in a year with the aid of greenhouse and net house facilities. Besides budding, veneer and soft wood grafting are also successfully attempted with about 70 per cent success. However, considering the efficiency, budding appears to be an ideal method for aonla propagation.

Propagation of Aonla in polybags/polytubes or *in situ* orchard establishment

(particularly in the drier areas) has been standardized and needs popularization. Aonla scion shoots can safely be stored and transported in sphagnum moss or moist newspaper for 5-7 days with ample success.

**Grafts of Aonla ready for sale in a Nursery**

**Grape (*Vitis vinifera)***

**Rootstocks:** Rootstocks are being used in Indian viticulture to overcome the adverse effects of salinity and drought and also to modify the scion physiology and morphology in terms of vigor, fruitfulness, bunches and berry characters etc. From available rootstock in the active Germplasm collection promising ones are under evaluation for drought and salt tolerance. Dogridge rootstock was known for its drought and salt tolerance in major grape growing regions of India and hence its compatibility with the promising varieties of grapes like Thompson Seedless and its mutants has been established. As a result it was widely accepted rootstock in India. Of late, Dogridge rootstock is posing few problems like uneven bud burst after pruning, less fruitfulness and increased deadwood in the cordons, which has been attributed to its more vigor inducing capacity to scions under heavy black cotton soils.

**Dogridge Rootstock for Grape**

The systematic evaluation of rootstocks revealed rootstocks of *V. berlandierii* × *V. rupestris* group like 99 R, 110 R and 1103 P etc. as most drought and salt tolerant. Amongst these, rootstock 110 R is gaining popularity because of its increased fruitfulness, moderate vigor, restricted uptake of chlorides and increased water use efficiency under moisture stress conditions. Maximum accumulation of phenolic compounds was observed in Thompson Seedless grafted on these rootstocks, which may offer fair degree of resistance to major grape diseases like downy mildew and powdery mildew. The propagation techniques like concentration of IBA, planting media, season of planting etc has been standardized for multiplying rootstocks by hard wood cuttings. Similarly time and stage of in situ grafting, chip budding and green grafting have been standardized to raise rootstock vineyards. Advanced grafting techniques like bench-grafting using grafting machines needs to be standardized in this crop. Work on molecular characterization of rootstocks to identify drought and salt tolerant gene has to be initiated to develop suitable rootstock for Indian condition, which can well adapt to semi arid tropics of India where grape is grown under larger area.

**Hardwood Cuttings:** For obtaining hardwood cuttings, 3-4 year old disease free vigorously growing mature vines, which have produced a good crop in the previous year, should be selected after October pruning. Cuttings from very young and very old vines or those subjected to heavy fruiting during the previous year should be avoided. Medium-size canes having inter-nodal length of 10-15 cm are desirable. 30-45 cm long cuttings of pencil size thickness with at least 3-4 nodes are cut from the middle portion of the selected canes. A cut should be made straight across 1cm below the node at the lower end of the cuttings, while slanted cut at the top is taken 2-3 cm above the bud. The cuttings are then immediately planted in bed or in polythene bags in the nursery. In case of delay in planting, the cuttings are stored by burying in moist sand or sawdust at 5 to $7^0$ C temperatures.

In nursery, the cuttings are planted in well-prepared flat beds of 1.2m width of convenient length. A mixture of Leaf mould, FYM, Sand and Super phosphate is thoroughly mixed in the soil before bed preparation. Cuttings are planted 20 cm apart in lines. While planting the cuttings at least two nodes should be inside the soil with one bud above the soil. Care should be taken to maintain the polarity while planting the cuttings, since grape cuttings planted upside down do not grow. Soil is pushed back into the furrows and pressed firmly around each cutting.

Cuttings can also be planted in polythene bags. Polybags (25x15 cm and 150-200 gauge) are filled with a mixture of soil, sand and FYM in equal proportion with Super phosphate. One or two cuttings may be planted in each bag. Preventive sprays to control common diseases are given during the growing period.

**Chip Budding:** Chip budding is the best method for propagating vines on rootstocks. In this method a wedge-shaped piece containing the bud (chip) along with a portion of wood is removed from the desired variety. The scion buds should be plump and taken from well-mature healthy canes, equal in maturity level and thickness to that of the rootstock.

A notch, sufficient to accommodate the chip, is made on the rootstock 10-15cm above the ground. The chip is placed in this notch and wrapped with a polythene strip exposing the bud.

Normally two budding are done on every mature stem 15 cm apart. When these buds sprout and grows to about 15 cm, the rootstock portion above it is cut off. The sprouts on the rootstock below the bud joint are removed regularly.

**Banana (*Musa sp*)**

**Selection of Suckers:** Select sword leaf suckers of 1.5 to 2.0 kg weight which is free from diseases and nematodes. Trim the roots and decayed portion of the corm, cut the pseudostem leaving 20 cm from the corm and grade the suckers to size.

To avoid wilt disease in Rasthali, Monthan, Virupakshi and other wilt susceptible varieties, the corms may be dipped for 5 minutes in 0.1% Emisan solution (1 g in 1 lit of water). Pralinage is done with 4 g of Carbofuran 3 G granules per sucker. (Dip the corm in slurry solution containing 4 parts clay plus 5 parts water and sprinkle Carbofuran to control nematodes). Alternatively, dip the corm with 0.75% Monocrotophos, shade dry for at least 24 hours and plant. Sowing of Sunhemp on 45th day reduces nematode build up. Use tissue cultured banana plants with 5-6 leaves is a good practice.

**Banana suckers: Water sucker (L) and Sword sucker (R)**

**Vegetative Method:** Commercial bananas are seedless and propagated exclusively by vegetative means. The banana has a reduced underground stem, called the rhizome, which bears several buds. Each of these buds sprouts and forms its own pseudostem and a new bulbous rhizome. These daughter plants are called suckers. Banana is mostly propagated by rhizomes and suckers viz. sword leaf suckers and water suckers. Sword suckers have a well- developed base with narrow sword-shaped leaf blades at the early stages. Water suckers possess broad leaves, which do not produce healthy banana clumps. Suckers of 2-4 months age are selected.

Other planting materials are whole or bits of rhizomes. Basrai variety in Maharashtra is as a rule propagated by dormant rhizomes. After cutting the parent plant, the rhizomes are removed from the soil, stored in cool, dry place for about 2 months. During the resting period the remaining part of pseudostem at the bottom falls off, leaving prominent heart bud. Conical rhizome should be selected while flat rhizomes to be rejected. The weight of the rhizomes should be 500-750 g .It should be 3-4 months age at planting. Very small rhizomes will give bigger size fruits with late flowering while bigger size rhizomes flower early but bear small size fruit/bunches.

Since banana is highly unstable in genetic constitution, the suckers/rhizomes should be selected from plants, which are healthy, having all the desirable bunch qualities and high yielding ability possessing at least 10 hands in a bunch.

**Tissue Culture:** Now-a-days banana plants are propagated through tissue culture. Varieties like Shrimanti, Gross Michael and Grand Naine (G-9) are commonly produced using tissue culture technique. Normally disease free plantlets with 3-4 leaves are generally supplied in pots for raising secondary nursery. Plants are initially kept in shade (50%) and as they harden, shade is reduced gradually. After 6 weeks, plants do not require any shade. Normally two months of secondary nursery is good enough before the plants to be planted in the field.

**Coconut (*Cocos nucifera*)**

**Mother Palm Selection:**

The palm must have a straight stout trunk with even growth and closely spaced leaf scars, spherical or semi-spherical crown with short fronds, short and stout bunch stalks without the tendency to drooping, more than 30 leaves and 12 inflorescences carried evenly on the crown, inflorescence with 25 or more female flowers, consistent yield of over 100 nuts per year, 150g copra per nut, absence of disease and pest incidence.

**Method of Seedling Production:**

1. **Maturity of Seed Nut:** Generally, 10-12 month old mature nuts are used for seed purpose. The mature nuts should be harvested when at least one nut in the oldest bunch starts to dry.
2. **Method of Harvest:** Rope harvest of seed nuts is recommended from the trees that are very tall and in places where the ground is hard.
3. **Selection of Seed Nuts:** Seed nuts are to be selected from the center of the bunch, as development of nuts at top and bottom extremities may not be uniform leading to poor germination and poor quality of seedlings.

**Coconut Nursery**

4. **Preservation of Seed Nut:** Harvested seed nuts are stored in shade to prevent drying of nut water. The seed nuts are generally stored till their husks become completely dry. Seed nuts of the tall variety can be stored for two months whereas the seed nuts of dwarfs should be sown within 15 days of harvest.
5. **Nursery Site:** The nursery site should preferably be in a level and well-drained area and should have loose or light textured soil. It should have a good source of water for irrigation. The nursery site should have proper shade. It should be accessible for transportation of the produce. It should be far from potential sources of coconut insect pests and diseases.

a. **Seedbed Preparation:** The seedbeds should be prepared in an area having loose and well-drained soil. The seed bed should have 1.5 m width, 10-20 cm height to provide drainage and of convenient length with 75 cm space between beds. The seedbeds should be drenched with Chlorpyriphos @ 0.05% before sowing of the seed nuts. To prevent bud rot/dry rot in the seedlings, the nursery can be drenched with Mancozeb @ 3% solution.
b. **Sowing of Nuts:** The seed nuts are sown in rows with spacing of 30 cm (between rows) and 30 cm (between nuts) with four or five rows per bed. The nuts may be planted either horizontally with the widest of the segments at the top or vertically with stalk-end up. The nuts are then covered with soil, such that the top portion of husk alone is visible. Only seed nuts with nut water should be selected for sowing.
c. **Poly Bag Nursery:** Poly bag nursery can be adopted for producing seedlings with greater vigour. The seeds can be sown in black polythene bags of 500-gauge thickness, 45x45 cm size for bigger nuts and 30x30 cm for smaller nuts. The bottom of the bags is to be provided with 8-10 holes for draining the excess water. To fill bigger bags around 10-12 kg and for smaller bags around 7-8 kg of potting mixture will be required. The commonly recommended potting media are top soil mixed with sand in 3:1 ratio or fertile top soil, sand or coir dust and well decomposed and powdered cattle manure in the ratio of 3:1:1. Red soil, well decomposed cattle manure and sand in 1:1:1 can also be used.
d. In order to produce poly bag seedlings, initially the seed nuts are sown very closely and allowed to germinate in a pre nursery bed. The seed nuts start germinating about three months after sowing. The germinated nuts are picked out from nursery once a week till 80 % of nut germination or 5 months from sowing, whichever is earlier. The germinated nuts are then placed in the half filled bags with the sprout positioned upwards in the centre of the bag and sufficient potting mixture is added to fill the bags up to two-third portion and the sides slightly pressed to keep the nut firm. Usually the poly bag seedlings are maintained for about 8 to 10 months. The size of the poly bag nursery bed can be 6x3 m with about 1 to 1.5 meters spacing between beds for hose irrigation and other cultural operations.

## 7.2.3 Mass Scale Production of Vegetable Plants

A good quality seedling production is very essential for getting higher yield and quality of produce. Vegetable seedling production is a specialized activity and farmers buy the seedlings from these nurseries. Vegetable seedling production system has changed in recent years in the intensive vegetables growing areas. Seedling production has come up as a specialized enterprise in these areas.

**Seedling Production Using Seedling Trays:**

It is already a commercial venture to produce the seedlings of tomato, capsicum, cauliflower and cabbage hybrids using seedling trays and protective structure. Earlier the seedlings required for transplantation were produced by the farmers themselves. This practice was feasible until they used the comparatively low cost open pollinated

vegetable varieties. Nowadays many progressive farmers have come forward to produce quality using seedling trays. They make these seedlings available for sale to the other farmers. Papaya seedlings can also be raised in trays which are bigger in size. This method is mostly adopted for raising seedlings of F1 hybrids since the cost of the seed is quite high. The vegetable seedlings are produced under protective structures such as insect proof net houses, shade houses and low cost naturally ventilated greenhouses.

**Different Types of Protrays**

**Advantages of Raising Seedling in Trays:**

1. Growing in seedling trays with right growing media helps in proper germination as it provides independent area for each seed to germinate and grow.
2. Seedling mortality or damping off diseases are reduced by using sterilized growing media. This results in uniform and healthy growth of all seedlings.
3. The use of trays enables easy handling and economy in transportation. The use of trays improves germination and saves a lot of expensive seeds.
4. Root development in seedlings is better and root damage while transplanting is almost avoided. This results in uniform crop with early maturity.

**Protected Structure for Raising Seedling:**

The seedling trays are commonly kept under nylon net house or poly house. Net house is found to be cost effective and feasible structure to grow vegetable seedlings. Seedling raising can also be done in low cost greenhouse or wooden polyhouses.

**Seedling Trays:**

Seedling trays are also called as pro-trays (propagation tray) or flats, plug trays or jiffy trays. The dimensions of the trays generally are 54 cm in length and 27 cm in breadth and cavity depth of 4 cm. These trays are made of polypropylene and re-usable.

Life of the tray depends on the handling of the seedling trays. Seedling trays have been designed in such a way that a sapling gets a pre calculated growing media and the right amount of moisture as the trays have pre punched holes to each cavity for proper drainage of excess water and also right spacing.

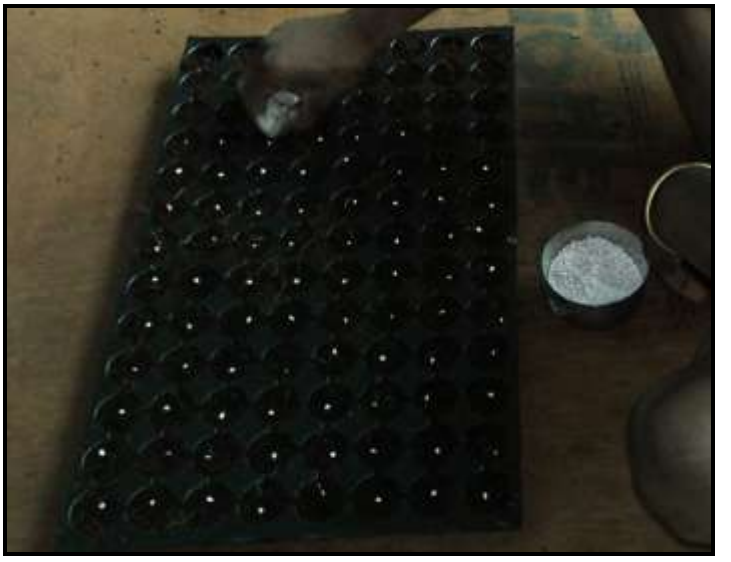
**Filling up the Tray with Media**

**Growing Media for Seedling Trays**

Sterilized commercial growing media are better as the incidence of seedling diseases is less or nil and they contain right amount of moisture. The most common growing medium used is coco peat, which is steam sterilized to prevent nursery diseases. Coco peat is a by-product of coir industry and it has high water holding capacity. It should be well decomposed, sterilized and supplemented with major nutrient sources before using. Basically coconut fiber powder is low in nutrients and high in lignin content. Thus it needs to be properly decomposed by adding major and micronutrients and microorganisms. Other growing media which have given good result are vermicompost and sand mixed in equal proportions.

**Method of Seedling Raising**

1. Fill the seedling tray with appropriate growing medium such as coco peat. Make a small depression for sowing (0.5 cm) by fingertip in the center of the cell. Alternatively, depression can be created by stacking about 10 trays one over other and pressing the trays together.



**Sowing Seeds in Trays**

2. Sow one seed per cell and cover by coco peat. No irrigation is required before or after sowing if coco peat contains enough moisture.
3. Keep about 10 trays one over the other for 3 to 6 days, depending on the crops. Cover the entire stack of tray with polyethylene sheet. This arrangement ensures the conservation of moisture in the seedling trays until germination and hence no irrigation is required till seedling emergence. Care must be taken for spreading the trays when the seedling is just emerging to avoid etiolation.
4. Seeds start emerging after about 3-6 days of sowing depending upon the crops. Then the trays are kept spread over a bed covered with polyethylene sheet.
5. The germinating trays are then irrigated lightly depending upon the prevailing weather conditions. The trays are also drenched with fungicides as a precautionary measure against seedling mortality.
6. Seedling trays are watered daily, or as needed using water can or a hose with a fine sprinkle attachment. Do not over irrigate the trays to avoid leaching of nutrients and favorable microclimate for disease.
7. The media may need to be supplemented with the nutrient solution if the seedlings show deficiency symptom. Apply 0.3 per cent (3g/litre) of 100 percent water soluble fertilizer (19 all with trace elements) twice (12 and 20 days after sowing).
8. Protect the trays from rainfall by covering the polyethylene sheets in the form of low tunnel.
9. Harden the seedlings by witholding irrigation and reducing the shade before transplanting

**Use of Nylon Net**

It is important to have vegetable seedlings that are free from insects, pests and disease problems. The earlier the plants are infected with pests or diseases, the more severe the effect on the field crop growth and yield. In this direction, growing vegetable seedling under cover using insect proof nylon net (40-50 mesh) is a good practice. Use

*Casuarina* or bamboo poles or GI pipe to support the net. UV stabilized and properly stitched nets last for 6-8 years.

**Solarization for Nursery Bed Sterilization**

It is a method of heating soil through sunlight by covering it with transparent polythene sheet. This method is used to control soil borne diseases including nematodes. This method is used for the disinfection of raised nursery bed to produce healthy seedlings of vegetable.

Other additional beneficial effects include control of weeds, insect pests and release of plant nutrients resulting in increased crop growth. Solarization is a non-chemical alternative for disease, insect pest and weed control.

**Method of Preparation of Raised Bed**

1. Add and thoroughly mix the organic manure in the soil to be used for making raised beds.
2. Bring the bed to field capacity by irrigating. Cover the nursery beds with 200 gauge transparent polyethylene film as tightly and closely to the ground as possible.
3. Leave the beds covered for 30-40 days. The soil temperature of the nursery bed thus covered can go up to $52^{o}$ C in summer months.
4. Check the sheets for the tear and if found torn out, seal with transparent tapes.
5. After 30-40 days, remove the polyethylene cover. Sow seed with least disturbance to the top soil in the bed.
6. With CPP manure slurry – will help to overcome seed borne & soil borne pathogen attack.

## 7.2.4 Mass Scale Production of Flower Plants

Production of healthy and disease free planting material is difficult task and required lot of experience, planning and management. Quality planting material (seed/saplings/bulbs etc.) is the basic requirement for successful flower production for market or exhibition. Generally, plants are produced by two methods, sexual and asexual or vegetative. In India sexual method is followed mostly in flowering annuals (seasonal flowers). There are several flowers which are not normally propagated from seeds but bred by breeders through seed to get new hybrids. Some of these plants are rose, chrysanthemum, gladiolus, carnation, orchid and dahlia etc. Large numbers of flower plants are also produced through vegetative means like cutting, layering, budding and asexual organs like corm, bulb and tubers. Therefore, the vegetative production technology of major cut flowers is discussed below in order to facilitate the production of quality planting material.

**Mass Scale Production of Chrysanthemum**

Chrysanthemum seeds should be sown into the prepared soil where they are kept for 2 months. Seed may also be sown indoors for transplanting. The seed are sown after 15 February either in earthen pots or nursery beds. The seeds are covered with a thin layer of

leaf mould and soil and watered. They germinate within 7-10 days. Seedlings are ready for transplanting within 40 days. Seeding propagation method is not used normally for routine cultivation. The temperature of the rooting medium must be kept at a constant 20-24 $^0$ Celsius. Germination can take 8-25 days in case of Chrysanthemum.

Rooted suckers are planted in field during January for developing stock plants. To reduce profuse branching, regular pinching is necessary. Some of those stock plants are used as potted plants for flower show and other display. The first pinching is performed in April, second in May and third in June. After third pinching, cuttings are taken from these mother plants. Otherwise, pinching is continued in other lot of stock plants.

Plants are also propagated by rooting terminal cuttings. These vegetative cuttings are removed from stock plants maintained under long day conditions to inhibit flower bud formation. The terminal cuttings which are 8-10 cm long are removed from stock plants and placed directly into the rooting medium. To enhance development of roots, basal ends of the cuttings are dipped in a talc powder containing 0.1-0.2% IBA. The greenhouse temperature should be between 15-18$^0$ Celsius and rooting medium temperature between 18 and 21$^0$ Celsius. 500-600 cuttings are planted per square meter of medium, depending on size of the lower leaf of the cultivar. Fine misting is done intermittently on the cuttings during day time until rooting is accomplished. The mist is usually turned off for a day or two before cuttings are removed for hardening. Cuttings are well rooted in 10-20 days depending on cultivation and season. Cuttings with root length of 1.5-2.0 cm are desirable since longer roots makes planting difficult.

Any porous mixture that is non toxic can be used as a rooting medium. Perlite plus sphagnum peat moss is perhaps the most common medium. Vermiculite, sand and a sandy soil mixture have also been used as rooting media. Total salts below 15 milliequivalents per liter for mist system does not affect rooting. However magnesium should not exceed 70 per cent of total salts. High percentage of sodium i.e., more than 67% of total salts will cause "red root". Calcium is necessary for good rooting. Application of gypsum or ground lime stone @ 20-30 kg/100 square meters area can be broadcasted over the surface of the medium prior to the planting of the cuttings.

**Mass Scale Production of Carnation**

Carnation is multiplied vegetatively by stem cuttings. Seed propagation is normally practiced for raising border carnations as well as for the purpose of hybridization. Specialist propagators use micro propagation for producing diseases free plants.

Seed are sown about 0.25 cm deep in a well drained mix. Make sure the compost is moist but not wet. Mist spray occasionally and keep it moist. The seeds will germinate in 2 to 3 weeks. The seedlings are transplanted in pots or in the ground when large enough to handle. The plants begin to bloom in 6 months or a year.

Layering is the easiest way to propagate carnation and the plants will do these themselves once mature. Observing a mature clump of carnations, seek out sturdy stems pointing away from the centre of the clump. These stems are often rooted. If not, rooting can be promoted by bending them down to touch the soil. These stems must be pinned to the soil till they root. Any flowers growing on the particular stem must be cut off. The new plant is cut from the mother plant when the roots are 4 to 5 inches long. The new

plant is planted in well drained soil.

Carnations can also be propagated by division. An entire non productive clump of an old plant is dug out. The plant segments are gently and carefully separated with hands or fork. Each new division is replanted in a well drained planting mix and kept moist.

A typical carnation cutting of 10-15 cm long with 4-5 visible pair of leaves weighing about 10 gm should be planted at 5 cm spacing in rooting medium. The rooting medium consists of one part of peat moss and two parts of perlite + sufficient calcium carbonate to bring pH near 7.0. The stem cutting should be broken from stock mother plant to avoid spreading of disease through wound. A rooting hormone should also be used. The cuttings normally are fully rooted in 21 days at rooting temperature of $15^0$ Celsius. If the bottom heat is maintained constant at $21^0$ Celsius the rooting time can be reduced to 15 days. The cuttings are watered through intermittent mist on bright warm days. Full sunlight is preferred for carnation rooting with proper misting.

**Carnation Seedlings**

Sanitation is important in propagation and rooting medium should be steam pasteurized for every successive group of cuttings. The dipping of cuttings in fungicide solution should be avoided, since bacterial wilt disease can be spread with dips. The drenching of cutting over bench is idle for applying of fungicides. Usually applying of nutrients during rooting is not necessary if adequate nutrient status maintained in the stock plants. Foliar fertilization of cuttings can be done.


**Depotting and Transplanting of Carnation into Medium**

The propagation by vegetative lateral shoots of the flowering plants should be avoided. Since disease are easily perpetuated in this type of propagation. Offsprings produced by this method have a declining plant vigour and productivity. In order to produce disease free plants, stock plants should be grown on raised benches in pasteurized media. These plants should be kept in vigorous and vegetative conditions and maintained by drip irrigation to keep foliage dry. Plant should be sprayed frequently to prevent foliage disease and insect damage. Stock plants should be used only for one season of cutting production.

**Mass Scale Production of Roses:**

Roses can be propagated by seeds, cuttings, grafting and buddings. Seed propagation is used by rose breeder for the development of new varieties whereas the T-budding is used for commercial production of the plants. The budding is done over the rooted root stock of *Rosa odorata* which is most commonly used root stock in India. Some times *Rosa indica, R. multiflora* are used for the production of rooted root stock and further budding. *R. multiflora* is a popular rootstock in South India.

**Production of Rootstock of Roses:**

The 25-30 cm long semi-hard wood cuttings are planted slanting in well prepared beds during December to February from rootstock mother plant. The cuttings are planted at $45^0$ with the spacing of 30x15 cm. The field is irrigated as soon as the cuttings are in place to settle the soil around the base. After 20-30 days of planting the rootstock sprout and grow. During this period adequate soil moisture should be maintained. The moisture stress can cause the wilting among the cuttings. Proper care is practiced in field beds up to June.

**Lifting of Rootstock of Roses:**

The rooted cuttings are lifted during 15th July to 30th July and planted in budding block/ polythene bags for budding. The rooted rootstocks are pruned up to the height of

30-45 cm and one to two shoots are retained. The plants are placed in the 15-20 cm deep pit and pressed firmly to avoid the air space. The planted rootstock sprout in 20-30 days. They produce newer shoots from base and these are utilized for budding.

**Budding of Rootstock in Roses:**

The budding procedure consists of making a vertical and horizontal cut in the rootstock to form a "T". The T is placed well below the shoot that arises from the rootstock. Cuts are made only to the depth of cambium layer. An eye is removed from the marked cultivar making a shallow slicing cut to form a shield like piece as backing for the bud. It is inserted between the flaps formed by the bark on either side of the T. A budding tape is wrapped around the shank of the stock above and below the eye to hold it in place. The budding operations are completed by the 15$^{th}$ February.

Three to four weeks after budding, the rootstock is cut approximately one-third of the way through directly above the inserted bud and top is broken over. This places the bud in an apical position on the shank of the rootstock, where it begins to grow. Three weeks after the tops are broken over they are removed entirely from the plant. Top removal is done in two stages to prevent the complete defoliation at any time. The digging of the budded plants is carried out in mid of October and completed by the end of January.

**Budded Rose**

**In Vitro Propagation of Roses:**

In vitro propagation of roses has played a very important role in rapid multiplication of cultivars with desirable traits and production of healthy and disease-free plants. During the last several years, different approaches have been made for in vitro propagation of roses. Micropropagation is done using apical buds or nodal segments. It is very necessary to study the specific nutritional requirements of the cuttings at different growth

stages in micropropagation. In rose, there are several reports which indicate rapid regeneration and multiplication through organogenesis or somatic embryogenesis.

**Rose Cuttings:**

Take cuttings from stems that have flowered, just after the petals have fallen, but before new growth begins from the leaf buds. Cuttings should contain about four to six nodes (leaf buds). Trim about 1.25 cm above the top node and the same below the bottom node. Remove leaves from the lower half of each cutting. Let there be two or three leaves at the top of the cuttings as such cuttings tend to root more successfully. Using a razor-sharp blade to make two or three very shallow vertical cuts on the lower end of each cutting. Cut only through the bark, not into the wood. Rooting hormone should be applied by dipping the end of the cutting into water, then into the powder. The excess powder must be removed by shaking off the excess. Make holes in the medium with a pencil. Each hole should be large enough to insert a cutting without scraping off the rooting hormone and deep enough to insert it about half its length. Firm the medium around the cutting.

**Mass Scale Production of Gladiolus:**

**Cormel Production:**

Gladiolus corms are propagated from cormels which grow in clusters on out growths between mother and daughter corms. Mostly the large size of cormels is used for planting stock production. Cormel stocks should be chosen carefully to prevent the spread of disease into developing corms. The corms should be preferably from healthy and disease free block.

The cormels should be treated in hot water (53-55$^0$ Celsius) for 30 minutes to eradicate latent fungus, insects and nematodes. Two days prior to treatment, cormel should be covered with warm water (32$^0$C) to soften the husk. The treated cormels should be air-dried in thin layers in sterilized trays and then placed in cold storage at 2-4$^0$ Celsius until planted. Dormancy of large cormels is usually broken within four months of treatment. Root bud swellings indicate that cormels are ready to be planted. It is a good practice to soak cormels in water for 2 days just prior to planting to ensure uniform sprouting.

The moist cormels are planted in single row in 10-13 cm wide furrows spaced 60-75 cm apart. The small corms are dug up with a modified potato digger. Yield of around 100 corms larger than 1.3 cm diameter can be harvested per meter of row when large cormels are used. Corms from 1.3 to 2.5 cm diameter are called “planting stock” and are used for the production of flowering size corms.

**Planting Stock Production**

Planting stock treatment is similar to the treatment of cormels except the temperature of the fungicide suspension is decreased to about 43$^0$C and the time of submergence is limited to 15 minutes. Small corms less than 2.5 cm diameter are planted in one or two rows per bed at a depth of 6-8 cm. 50-80 corms are planted per meter of row, depending upon the size of corms. The soil should contained adequate moisture and

nutrition for good growth. Irrigation should be stopped prior to harvest to prevent rotting of corms in the field and to facilitate the cleaning of the new corms.

Removal of flowers spikes improves corms size but many producers allow the first flower open to observe purity of the stock and allowing rouging of undesired plants. Corms should be cleaned and dipped in a fungicide solution within two days of digging to obtain maximum effect of fungicide. The corms produced in warm region are dormant and require 3-4 months of cold storage (2-4$^0$Celsius) to break this dormancy.

**Mass Scale Production of Tuberose Bulbs**

Tuberose is multiplied through bulbs which are planted from February to May and bulbs of 1.5 cm and above diameters are selected for planting. The 8-10 bulbs are planted per meter of row and they are spaced at 30 cm from each other. Row spacing is also maintained at 30 cm. The bulbs are placed 5 to 8 cm deep over a ridge or in a flat bed. The bulbs sprout 10-15 days after the planting, depending upon the temperature. Timely irrigation, weeding and broadcasting of nitrogenous fertilizer is practiced to maintain good growth. The bulbs are lifted in the month of October and November. The bulbs are snapped off from the clump and kept in shade for two to three days. The soil is removed from the bulbs and bulbs are subjected for storage in normal ventilated conditions. The multiplication of bulbs ranges from 10-15 times the original number.

**Mass Scale Production of *Gerbera***

*Gerbera* can be propagated by both sexual and asexual methods. Most of the commercially grown cultivars are propagated through vegetative means, to maintain uniformity and genetic purity. Among the vegetative means, multiplication through divisions of clumps is the most common method used for several decades. Gerbera can also be propagated through cuttings. A tissue culture procedure has been proven to be commercially practical in gerbera propagation. This method enables a million fold expansions per year of a desired plant. Micropropagation of gerbera is being used in many countries from a range of explants. In tissue culture studied so far, plant regeneration was uniformly achieved with different explants as the source material. Bud regeneration in Gerbera may represent an effective alternative to the current methods of micropropagation via axillary branching, provided that the phenotype and flower production of the regenerates are maintained. Most of the work has been carried on plant regeneration by adventitious organogenesis from capitulum, shoot tip, leaf, petiole and other parts of the plant.

**Gerbera Plantation in Polyhouse**

For asexual reproduction, division of clumps may be done at the end of the rainy season. Individual sucker can be planted in pots containing a well-drained media. The single potted sucker needs to temporarily stay in partial shade for 2-3 months before they can be transplanted in the bed under full sun. Clumps are usually composed of about 2-4 suckers. Though this is a slow process, a much faster technique of propagation was developed, wherein a suitable plant is kept without water for three weeks. Its roots are then pruned and the sucker is planted in peat and held at 80% relative humidity at a temperature of 25-30$^0$C. This method produces 30-50 buds per plant. At 2-3 leaf stage, the buds are severed from the mother plant and treated with a rooting hormone before they are planted to a sterile media. They will be ready for transplanting in about 2-3 months.

**Seed Propagation**:

The seeds of Gerbera are expensive, delicate, and sensitive to germinating conditions. The Gerbera crop requires 14 to 18 weeks duration from seed to flower. Considering this fact many small growers prefer buying seedlings from specialist propagators. Seeds are packed in moisture-proof packages and should be stored under cool conditions away from strong sunlight until sowing. Once the package is open, all seeds should be sown at once because they lose their viability very quickly when exposed to room conditions. Though it is not advised, unused seed can be resealed in the package and stored in a refrigerator for a short time. Gerbera seed can be sown in open flats or in a variety of plug flat sizes. The more common practice is to sow into a variety of large plug trays that have 72 to 288 cells per tray. Some growers sow into small celled trays and then transplant to larger trays or pots. This allows the seedlings to be sorted by size for a more uniform crop but requires more labor. Water the sowing media before sowing. The seeds are covered with a thin layer of fine grade vermiculite sand.

**Mass Scale Production of Jasmine**

Jasmine is commercially multiplied by cuttings. However, propagation by layering and even by grafting (approach or inarching) and budding is possible. To facilitate the

rooting in layering (ground or air layering) or cuttings, a 1000-2000 PPM of IBA preparation is applied to the basal portion for rooting. A 15 centimeters long shoot tip cutting with four leaves and five distal buds are placed in a rooting media of vermiculate or any good soiled media and then rooted in a mist chamber. While planting in the open, hardwood or semi-hardwood (15-20 cm long) cuttings with or without leaves are used for multiplication. The hardwood cuttings of *J. sambac* may be planted directly in situ during rainy season by which a success of 70-80 per cent rooting may be obtained. Layering of tender shoots ensures better and quick rooting and multiplication is done in rainy season or June-July. High humidity is maintained to promote rooting of the cutting.

**Care of Flowering Nursery Plants:**

Care of flowering nursery plants is an important operation of the nursery activities. The young seedling stock and rooted cuttings as well as flowering nursery plant require proper care and nourishment. The following operations are to be attended to regularly in the flowering plant nurseries.

1. **Shifting of Plants:** The flowering plants grown in the pots or polybags are to be shifted once in 2-3 months to avoid root penetration into the soil. If the tap root penetrates deep into the soil the chances of mortality increases. Hence shifting of grafted, budded and potted plants has to be done at regular intervals.
2. **Removal of Rootstock Sprouts:** One has to keep a constant eye on the sprouts arising on the rootstock which are to be nipped off as and when observed. This encourages rapid growth of scion shoots.
3. **Nutrient Management:** To get good growth of grafts and potted plants they are to be fed with all major and minor nutrient elements. Application of one tea spoonful of neem cake at 45 days interval and DAP 0.5% solution will enhance the growth of flowering nursery plants. Foliar sprays with soluble fertilizer mixtures like 1 % polyfeed (19:19:19) and correction of micronutrient deficiencies is also of paramount importance in maintaining the healthy flowering nursery plants.
4. **Pest and Disease Management:** Root rot, leaf spots, die back and canker in citrus are some of the important diseases, which are commonly observed in fruit nurseries. Against root rot diseases, drenching with 0.3 per cent Blitox or 0.2 per cent Ridomil or Kavach is useful in checking the incidence. Bavistin 0.1 % or Mancozeb 0.2% or Captan 0.2% or Blitox 0.3%, are effective against leaf spot diseases. For control of die back disease the affected portion may be pruned up to the healthier portion and the cut end has to be smeared with Bordeaux paste/ Blitox paste. Pests like leaf eating caterpillars, thrips, ash weevil etc. can be checked by prophylatic sprays with Monocrotophos 1.6 ml per liter of water.
5. **Weeding:** The nursery beds, polybags, trenches, channels and bunds, paths and roads should always be kept weed free. This not only encourages good plant growth and also improves the image of the nursery.
6. **Provision of Partial Shade:** It is essential to provide partial shade to the nursery plants in summer season especially in arid regions where the humidity and water availability are less. Depending upon the climatic conditions prevailing in the area,

50% or 75% shade nets can be utilized for this purpose.

7. **Removal of Bandage Material:** A successful graft/bud union is indicated by the production of two growth flushes. The polythene strips or wax cloth used for bandaging the union should be removed to prevent girdling of graft joint and ultimate death of grafts/ buddlings.
8. **Watering:** Nursery plants require adequate and regular supply of water to keep the potting mixture in pots/bags moist. If the grafts are kept in trenches they are to be irrigated once in 3-4 days, while in open beds, daily watering is essential in winter and twice a day in summer season. For green house grown plants, watering once in two days with overhead upside down microsprinklers (arranged at 4' distance) is optimum. Avoid stagnation of water in polybags by puncturing the bags at the lower side with a sharp 18 guage rod.

## 7.2.5 Branding and Marketing of Nursery Plants

**Branding of Nursery Plants:**

In an early stage of development of a nursery business, entrepreneurs should decide on the symbol or image that will be used to identify the products of the nursery. These symbols and images make the plants recognizable among the competitors. The 'logo' is used on all plants in a producer's range and helps to develop a brand image. The label on a package is the first point of contact between a customer and the nurseryman. It should therefore be considered as part of the marketing strategy. Appreciation of products can develop into loyalty to the brand. These repeat buyers are the type of customers that are required to build up constant sale of plant.

The label not only gives customers information, such as the type of plant, planting method and other information but the design and the material used also creates an impression on the customers. In general a simple, uncluttered image on the label is better than a complex design. The brand name or the name of the nursery should stand out clearly and if pictures are used, they should be an accurate representation of the plant. Color can be used to emphasize a particular feature. Browns and greens are associated with 'nature' or natural products, with an image of health, eco-friendly and good quality products.

In some countries there are legal requirements on the design of the label and the information that is included. As a minimum in most countries, the following information should be clearly visible:

- Name and address of the nursery and nurseryman
- Botanical name, common name, variety etc
- A seed sowing/grafting /planting/ transplanting date
- Used media/fertilizer/water etc.
- Instructions for planting.
- An 'e-number' if the plant is to be export
- A bar code.

**Marketing Strategies**

Before entering the nursery business, a market analysis is necessary to determine what opportunities exist to sell plant materials in the local area. Most new farms begin with only a few acres of production and market in a 75 km radius. A market analysis includes finding out what crops other nurseries grow successfully in the region. The analysis also evaluates competition potential with the other nurserymen from the area.

Marketing starts with a decision about what to produce and at what volume. Nursery managers need to:

1. Determine what kind of customer the nursery will attract and what size of plants those customers want. Mass traders demand large volumes of a few popular plant species. Mass merchandisers purchase smaller sized plants. These customers may not care about buying specific plants, but focus on obtaining a good mix of fast moving materials. Demand from these customers is seasonal. Plants in fashion vary from year to year.

   There are several disadvantages of dealing with mass traders. These customers want instant shipment, pay the lowest price for plants and often do not take care of plants after receiving them, which can reflect poorly on a nursery.

   Landscapers look for large, high-quality specimens carefully identified by flower cultivar for flower bed purpose. Landscapers generally buy plants from a limited number of producers but choose among many plants and plant sizes. Landscaper purchases are spread out through the year, with an emphasis on seasonal planting.

   Retail outlets include mail order, Web sites, farmer markets and starting a landscaping business. Sales at farmer markets will be local, but local markets can mean a weekly travel of 50 to 100 kms to a large metropolitan area. Potential customers all share a common need to get uniform, well-grown plants from a producer without having to inspect the crop before each purchase.
2. Keep up with trends in buyer preferences. Constant monitoring of customer characteristics and purchases is crucial. Advertising and promotion never end. Chain stores now carry nursery items. Convenience and escalating fuel prices promote one-stop shopping.
3. It is necessary to design the combination of plants which can maximize profits. Flowering plants fall into general categories of perennials, vines, bulbs and annuals. While most nurseries grow a range of plants, there is a trend toward specialization. Growing only native flower plants or only day lilies are viable niche markets. The production of specialty crops, such as Rose, Bougainvillea, Marigold, Aster, disease-free rootstock, and specialization in plants in short supply like uncommon plants are niche markets even small growers can serve.

Keep abreast of recent developments in the industry. Subscribing to trade publications and attending trade shows or conferences are good ways to learn about grower issues like plant availability, new varieties for specific needs, popular sizes, specific growing conditions and enhanced services. Enhanced services can include providing photographs of plants and making presentations to flower arrangement, flower show, flower bed, flower field and other potential customers.

Marketing is systems that will make consumers believe that they are buying something special. It is a system which meets the needs of the consumers and supplies the right amount of product when the customer needs it. Customer perceptions are not just about price and quality. They may also include status, enjoyment, attractiveness, convenience, health. Producers should decide which factors are special for their product and emphasize these in the promotion and advertizing of the product.

**Direct Marketing**

This is sales by the nurseryman direct to the consumer. Different studies show that many consumers prefer direct contact with the nurseryman/seller compared to an impersonal service, although the latter are in some cases more efficient. One of the main advantages of direct sales to consumers is the opportunity to reduce marketing costs and to add value to the product in this way, the profit margin is increased. Nurseryman need to become aware of existing marketing tools in order to maximize sales.

**Nursery Markets**

A nursery market is a form of direct marketing that is located in or within proximity of a community where growers sell directly to numerous customers. Cash sales and the possibility of selling under or oversize units that cannot be marketed through other marketing channels are the main benefits of this system for nurseryman. For consumers it provides the opportunity to buy new plants and to interact with nurseryman in an informal environment.

**Order Markets**

The nurseryman take order from the customer then prepares the seedling with desirable variety/ species of crop. These marketing systems are very popular and profitable for both nurserymen and customer. Customer gets healthy plants of desirable variety within short period and the economical losses and risk of over or under production is lowered for the nurseryman.

## 7.3 Glossary

**Air Layering:** A propagation method practiced in fruit crop like pomegranate.

**Budding:** Method of vegetative propagation where the scion is reduced to a single bud and is inserted into a rootstock.

**Corm:** A short, thickened underground storage organ formed usually by enlargement of the base of the main plant stem.

**Germplasm:** The genetic variability of a population of organisms.

**Hardwood cuttings:** Cuttings made from woody deciduous species and narrow-leaved evergreen species, such as grape.

**Integrated Pest Management (IPM):** A pest management method that utilizes all techniques of pest control like cultural, biological and chemical, in an integrated manner to keep pest populations below an economic threshold level.

**Pinching:** Breaking or cutting the uppermost growing point which promotes outward growth rather than upward growth.

**Seed coat:** The outer covering of a seed.

**Softwood cuttings:** Cuttings taken from soft, succulent, new spring growth of deciduous or evergreen species of woody plants.

**Stem cutting:** Any part of a stem used for plant propagation by separating it from the parent plant.

**Sucker:** A rapidly-growing, upright secondary vegetative shoot that develops from the root or stem of a plant.

**Tubers:** Enlarged underground stems serving as storage organs of starch or related materials like the potatoes.

## 7.4 Point To Remember

- Veneer grafting and soft wood grafting techniques can be used for large scale multiplication of mango propagation while stooling is the easiest and cheapest method of guava propagation.
- Patch/ Modified Ring Budding during mid of May to September gives 60 to 90 per cent success under north Indian conditions.
- A mixture of Leaf mould, FYM, Sand and Super Phosphate is thoroughly mixed in the soil before forming the nursery bed or filling the bag or pot.
- Select the banana sword leaf suckers of 1.5 to 2.0 kg weight which is free from diseases and nematodes.
- The seedlings production of tomato, capsicum, cauliflower and cabbage hybrids is done in seedling trays and under protective structure.
- Seed propagation in Rose is used by Rose breeder for the development of new varieties whereas the T-budding is used for commercial production of Roses.
- The tissue culture and divisions of clumps are the most common methods used in mass production of gerbera.
- To facilitate the rooting in cuttings of jasmine a 1000-2000 PPM of IBA preparation is applied to the basal portion.

## 7.5 Self Check Questions

1. Enlist the criteria for selection of mother plant and rootstock.
2. Explain in Short: Stooling in guava.
3. Describe the method of coconut seedling production.
4. Enlist the advantages of vegetable seedling production in pro-trays.
5. Explain the method of mass scale production of gerbera seedling.

## 7.6 Do It Your Self

1. Visit a fruit crop nursery and record your observations on the types of fruit plants propagated method of propagation used, care and maintenance of the plants, marketing and branding strategies, etc.
2. Visit a vegetable seedling production nursery and record most popular vegetable seedlings grown in trays and their harvesting and aftercare.
3. Visit a floriculture nursery and record your observations regarding special horticultural practices like pinching, desuckering, debudding, fertigation and watering.

# Unit 8: Ornamental Horticulture Nursery

***Index***



## 8.1 Introduction

The Indian culture is intrinsically tied to its flora, a fact that is reflected in the prominent role that gardens play in Indian society. A wide variety of ornamental plants are native to India due to its diverse geography. Many ornamental plants have been cultivated for their beauty and symbolic value in gardens around the country for hundreds of years. The native ornamental trees and plants of region evolve over long periods of time and adapt themselves to the local climatic conditions, water availability, pest resistance etc. Native plant species require little watering other than during the initial years of establishment. Selecting the proper plants is one of the most important elements when creating your ornamental nursery, keeping in mind the principle "Right Plant at the Right Place." This will determine the level of maintenance, water, fertilizer and pesticides. The native ornamental trees and plant also play a major role in supporting a large number of birds, insects, animals etc. for food and habitat requirements. When native ornamental trees and plants get increasingly replaced by exotic plant species, the ecological balance will shift in unfavorable directions for the existence of other dependent species and can result in ecological damages that cannot be reversed back.

**At the end of this unit, you will be able to know and understand:**

- Native plants in the region which are used for ornamental purposes.
- Identification of regional plant species used for ornamental purposes.
- Demand and supply situation of ornamental plants.
- Strategies for mass production of ornamental plants.
- Nursery plant branding, exhibition and marketing.

## 8.2 Content

### 8.2.1 Selection and Collection of Regional Ornamental Plants:

The selection and collection of native ornamental plants is carried out on the basis of utility of ornamental plants as follows:

**A. Ornamental Trees:** Ornamental Trees are perennial and tall plants with big trunks growing for several years and bearing flowers and fruits. On the basis of purpose of growing, ornamental trees are classified as;

1. Flowering Trees: These trees produce colorful flowers and are planted for their beautiful flowers, e.g. *Bauhinia variegata, Cassia fistula, Cassia siamea, Delonix regia, Plumeria alba* etc.
2. Shady Trees: These trees have round canopy or umbrella shaped crown. Leaves are large and dense so that no or very little sunlight is allowed under them. E.g. *Azadirachta indica, Ficus religiosa, F. benghalensis, F. benjamina, Pongamia pinnata* etc.
3. Avenue Trees: These trees are planted alongside avenues or roads, generally for shade or for flowers. E.g. *Cassia fistula, Grevillea robusta, Jacaranda acutifolia* etc.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | Flame of the forest (Palas) | *Butea monosperma* |
| 2. | Indian laburnum (Bahava) | *Cassia fistula* |
| 3. | Pride of India *(*Taman) | *Lagerstroemia indica* |
| 4. | Marukh | *Ailanthus excels* |
| 5. | Mast Tree (Devdar) | *Cedrus deodara* |
| 6. | Indian beech tree (Karanj) | *Pongamia pinnata* |
| 7. | Coral tree (Pangara) | *Erythrina stricta* |
| 8. | Peepal | *Ficus religiosa* |
| 9. | Arjun | *Terminalia arjuna* |
| 10. | Baheda | *Terminalia bellarica* |
| 11. | Sissu (Shisham) | *Dalbergia sisoo* |
| 12. | Kusum (Kusumb) | *Schleichera oleosa* |

**B. Ornamental Shrubs:** A shrub may be defined as a perennial plant having many woody branches arising from the base of the plant. Shrubs are classified as;

1. **Flowering Shrubs:** These shrubs produce spectacular flowers which are grown for mass effect and for carpeting purpose e.g. *Hibiscus Rosa sinensis, Caesalpinia spp., Bougainvillea ssp., Nerium indicum, Calliandra spp*. etc.
2. **Foliage Shrubs:** These shrubs are grown in the garden for handsome and richly variegated foliages. E.g. *Acalypha tricolor, Manihot* variegated, etc.

| Sr. No. | Common & Vernacular Names | Botanical Names |
|---|---|---|
| 1. | *Ardisia (*Kadna) | *Ardisia solanacea* |
| 2. | Indian Asystasia (Lavana valli) | *Asystasia indica* |
| 3. | Dwarf White orchid tree (Safed Kachnar) | *Bauhinia acuminata* |
| 4. | Indian barberry (Chitra) | *Berberis vulgaris* |
| 5. | *Cananga kirkii* (Chapa) | *Cananga kirkii* |
| 6. | Wild Jasmine (Van Mallika) | *Jasminum angustifolium* |
| 7. | *Coffea* (Coffee) | *Coffea arebica* |
| 8. | *Crossandra* (Aboli) | *Crossandra infundibuliformis* |
| 9. | Indian Paper Plant (Satpura) | *Daphne papyraceae* |
| 10. | Compact Deutzia (Suran) | *Deutzia compacta* |
| 11. | Brilliant Gardenia (Dikemali) | *Gardenia resinifera* |
| 12. | Asian Bushbeech (Kalishivan) | *Gmelina asiatica* |
| 13. | Parrot's Beak (Badhara) | *Gmelina philippensis* |
| 14. | *Hibiscus* (Jaswand)_ | *Hibiscus rosa-sinensis* |
| 15. | Cup and Saucer (Kapni) | *Breynia retusa* |
| 16. | St John’s Wort (Basant) | *Hypericum oblongifolium* |
| 17. | Ixora (Goravikatagi) | *Ixora pavetta* |
| 18. | Warer willow (Tev, Pakas) | *Justicia gendarussa* |
| 19. | Delek air tree (Anjan) | *Memecylon umbellatum* |
| 20. | Queen of the night (Parijatak) | *Nyctanthes arbortristis* |
| 21. | Pomegranate (Dalimb) | *Punica granatum* |
| 22. | Crape jasmine (Tagar, Chandni) | *Tabernaemontana divaricata* |
| 23. | *Thespesia* lampas (Raan Bhendi) | *Thespesia lampas* |
| 24. | Dabra (Pitvan) | *Uraria picta* |
| 25. | Arabian Lilac (Indrani) | *Vitex trifolia* |

**3. Climbers:** Climbers are group of plants which have weak stem and ability to climb up support with the help of modified organs for sunlight and air.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | Piluki | *Combretum extensum* |
| 2. | Hog Creeper (Garudvel) | *Entada rheedei* |
| 3. | Clove scented echites ( Malati) | *Aganosma dichotoma* |
| 4. | Helicopter Flower ( Madhavi lata ) | *Hiptage benghalensis* |
| 5. | Moon Flower ( Kinarwel) | *Ipomoea violacea* |
| 6. | Rangoon creeper ( Lalchameli ) | *Quisqualis indica* |
| 7. | Bread Flower ( Dudhi ki bel ) | *Vallaris solanacea* |

4. **Edges:** Lining and borders of flower beds, paths, lawns and shrubbery with brick, concrete, living plants etc is known as edging.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | *Alternanthera* (Kanchari) | *Alternanthera sessilis* |
| 2. | Burma Agrimony | *Eupatorium birmanicum* |
| 3. | *Justicia* (Karambal) | *justicia procumbens* |

**5. Hedges:** Shrubs or trees planted at regular intervals to form a continuous screen are called as Hedges.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | Peacock Flower ( Shankhasur) | *Caesalpinia sp.* |
| 2. | Karonda (Karvand) | *Carissa congesta* |
| 3. | Crape myrtle (Dhayti) | *Woodfordia floribunda* |
| 4. | Orange Jasmine (Kunti) | *Murraya paniculata* |

**6. Annuals:** Annuals or seasonal are the group of plant which complete their life cycle in one season or in one year.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | Cockscomb (Kurdu) | *Celosia argentia* |
| 2. | *Chrysanthemum* (Annual) (Shevanti) | *Chrysanthemum* |
| 3. | Globe Amaranth (Gul-e-makhmal ) | *Gomphrena globosa* |
| 4. | Butterfly Pea (Shankha Pushpa) | *Clitoria ternatea* |
| 5. | Balsam (Terda) | *Impatiens balsamina* |

**7. Bulbous Plants:** The plants which propagate themselves through modified underground stems are called as bulbous plants.

**A. Arisaema:** Hardy tuberous rooted plants which have curious looks. Generally does well on the hills and are planted in the spring for flowering during the rains. The flowering spathe looks like the hood of a cobra.

***Arisaema tortuosum* with Flower**

***Arisaema murayii* with Flower**

**B. Canna:** The leaves may be green, bronzy-green, or bronze colored and there are cultivars having streaked variegated foliage. Cannas are hardy and beautiful plants bearing flowers in different colors and shades. This is one of the best plants for growing in beds, especially in the midst of lawns. Cannas are generally propagated by the division of rhizomes. The best season for planting the rhizomes is just before the rains, i.e., during June-July. A sunny situation and rich soil are required for the cultivation of canna. The rhizomes are planted 7- 10 cm deep in the soil.

**C. Crinum**: These are tall growing plants with strap-shaped leaves. The plants are grown in borders, pots, and near pools. The plants like swampy or marshy and semi-shady places. Propagation is from bulbs. The flowering is profuse during the rains. The plants can remain in pots or borders for several years. It is a hardy plant needing very little care.

**D. *Gloriosa superba:*** It is a creeping plant which climbs with the tendrils. The long-lasting flowers open primrose-yellow and later turn to orange-red or dark red. The petals are long, twisted or wavy, and heavily corrugated. It is suitable for growing in pots or in ground. The flowers last long in vase. The tubers are planted horizontally in March-April and the flowering season extends from July to September. The plant needs a light soil and plenty of watering.

## 8. Cactus and Succulents

a. **Cactus:** The group of plants belonging to the family Cactaceae with characteristics like presence of arioles (spine-cushion), perennial fruits being one celled berry, dicotyledonous and flower petals arising from top of the ovary are called cactus. Example, Astrophytum, Echinipsis, Lobivia, Parodia etc.

**Cactus in Nursery**

b. **Succulents:** Plants with very fleshy foliage or stem or both, mostly inhabiting dry desert locations in open situations and capable of withstanding long hot spells of drought are called succulents e.g. Agave, Abe, Cotyceda, Euphorbia, etc.

**Nursery of Succulent *Kalanchoe sp.***

**Asclepiadaceae**

The economic importance of the family includes the use of some species of *Caralluma* such as *Caralluma edulis*, as green vegetables and the tubers of *Ceropegia* species as food.

**A. C*eropegia*:** Ceropegia are a group of very peculiar looking insect pollinated flowers. Many of these are endemic to Indian subcontinent and to be specific the Western Ghats. Some are listed as below: C*eropegia attenuata, C. bamesii, C. ciliate, C. ensifolia, C. evansii, C. fantastica, C. huberi*, etc.

***B. Caralluma:*** In India there are 13 species of *Caralluma* most of which are confined to Peninsular India. The habitats of this genus, particularly in the Western and Eastern Ghats and Vindhya ranges are fast disappearing due to mining activities. e.g. *Caralluma edulis, C. indica, C. lasiantha, C. nilagiriana, C. pauciflora,* etc.

***C. Brachystelma:*** Peninsular India is the second centre of origin of the genus *Brachystelma.* Species are distributed in the hill ranges of Madhya Pradesh, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Goa, Maharashtra, Gujarat, and Karnataka. Ten species of Brachystelma are found in India viz, *Brachystelma bourneae, B. bracteolatum, B. ciliatum, B. glabrum, B. kolarensis, B. maculatum, B. rangacharii, B. volubile,* etc.

***D. Hoya:*** The genus *Hoya* is widely distributed in the temperate regions of the Himalayas where species are under threat due to deforestation. Since forty percent of the forest cover in the Himalayas has been lost, substantial numbers of populations of Himalayan *Hoya* species have also been lost.

**Euphorbiaceae**

Within the genus *Euphorbia, 19* Indian species show succulence. Of these 16 are dendroid and three are geophytic. Some of the tree Euphorbias has been utilized as renewable sources of energy and also in making toys. E.g. *E. atoto, E. cattimandoo, E. cauduca, E. corrigioloides, E. epiphylloides,* etc.

**9. Palms:**

Plants in this group usually have straight, unbranched, cylindrical or columnar trunks at the end of which there is a spreading canopy of large pinnate or digitate leaves distinguishing the group from almost all other forms of vegetation.

| Sr. No. | Common & Vernacular Name | Botanical Names |
|---|---|---|
| 1. | Arecanut (pophali, supari) | *Areca catechu* |
| 2. | Coconut (Naral, Shriphal) | *Cocos nucifera* |
| 3. | Date Palm (Khajur) | *Phoenix loureirii var. humilis* |
| 4. | Snake palm (Ran-suran) | *Amorphophallus bulbifer* |
| 5. | Fishtail palm (Mari) | *Caryota urens* |
| 6. | Talipot Palm | *Corypha umbraculifera* |

## 8.2.2 Regional Demand and Supply Situation in Ornamental Plants

Consumer demand for nursery crops is driven by housing. Housing initiates the desire of homeowners to be surrounded by aesthetically pleasing environments. The number of hobby gardeners is ever increasing. Demographic experts cite three key demographic trends that show promise for horticultural industries.

- Landscape gardening as an enterprise has a brilliant future due to the emergence of Tourism and IT industry, which attracts a lot of foreign tourists and business personnel.
- More self-employment avenues are open due to flair in home gardening and indoor gardening. The flat culture spreading throughout urban India creates demand for indoor gardens, window sill gardens, bonsai, terrariums etc.
- There are agencies, which employ trained hands to periodically arrange flower vases and potted plants in offices and for functions, which is a lucrative business. Hence, the scope of this area is very wide spread in location.

Despite this optimistic outlook for the nursery industry, it's important to recognize that nursery products are luxury items and will experience reduced demand during periods of economic downturn. Industry insiders feel the nursery industry can ride through an economic downturn, as people will stay home and spend time in their gardens and buy plant material.

The demand of garden plants is also increasing in both municipalities not only due to the major events like Asian Games, World cup, International Expo, conferences, Meetings etc. but also to the expansion of the municipal gardens area and due to the construction of luxurious houses. For nurseries that are being developed to meet in-house seedling needs, the demand is already known. But, for nurseries that plan to supply

seedlings to other users, potential customers should be surveyed and detailed information collected to answer these questions:

- What species, number and size of trees are needed?
- When and where will these trees be planted?
- How long will these needs persist and will they change over time?

In particular, nursery developers planning on growing seedlings for government tree-planting projects should be aware that most contracts are awarded on a minimum bid basis and so profit margins are small. Seedling demand from government agencies can vary considerably from year to year. Therefore, potential nursery developers should carefully analyze their potential market and make certain that a sustained demand exists before investing in a nursery.

A variety of crops like spices, plantation crops, fruit trees, vegetables, aromatic and medicinal, ornamentals and other plants are grown throughout India. Hence, there is good demand for quality planting materials. Such possibilities can be effectively and efficiently utilized by the nursery owner.

## 8.2.3 Mass Production of Ornamental Plants

When the society changes to production and selling in the market system, it also changes to competitions and capitalist economic status with an emphasis on the importance of materialism. Marketing study concerning ornamental plant production surrounding metropolitan cities like Bangalore, Ooty, Pune, Delhi, etc indicates development and substantial increase in ornamental plants user community. So mass production of ornamental plants is needed.

**Multiplication of Ornamental Plants**

Plant propagation is the process of multiplying the numbers of a plant and perpetuating the plant or maintaining the youthfulness of a plant.

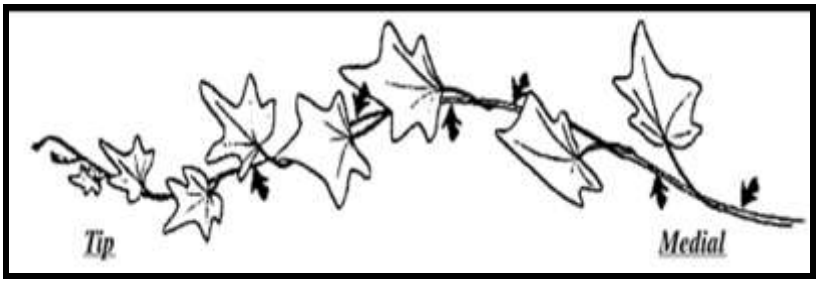
***1. Asexual Propagation***

Asexual propagation involves the vegetative parts of a plant including the roots, stems or leaves. There are several advantages to propagating plants asexually. It is the easiest and fastest way to propagate some species of ornamental plants. It may also be the only way to perpetuate some cultivars. The major methods of asexual propagation are cuttings, layering, grafting and budding.

**Cuttings**

**Stem Cuttings**: Numerous plant species are propagated by stem cuttings. Some can be propagated any time of the year, but stem cuttings of many woody plants must be taken in their dormant season.

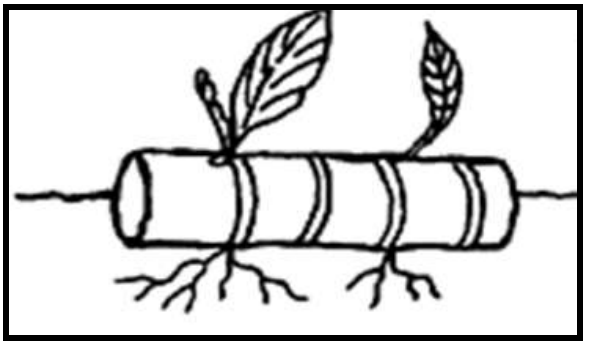
**Tip Cuttings:** Detach a 2 to 6 inch piece of stem, including the terminal bud. Make the cut just below a node. Remove lower leaves. Dip the stem in rooting hormone. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deep enough into the media to support it. At least one node must be below the surface, e.g. Coleus, Carnation, etc.




**Tip and Medial Cutting**

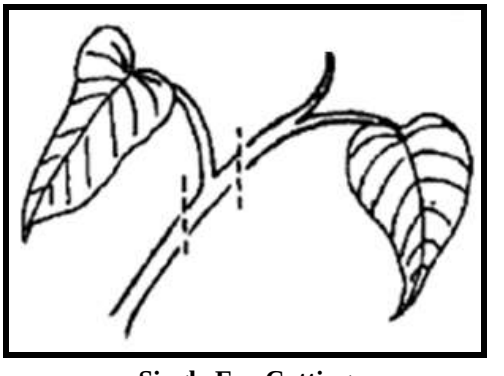
**Medial Cuttings:** Make the first cut just above a node and the second cut just below a node 2 to 6 inches down the stem. Prepare and insert the cutting as you would insert a tip cutting. Be sure to position the cutting with the correct side up. The correct side can be inferred with the help of the axial buds which are always situated above the leaves.

**Cane Cuttings**: Cut cane-like stems into sections containing one or two eyes or nodes. Lay horizontally with about half of the cutting below the media surface with the eye facing upward. Cane cuttings are usually potted when roots and new shoots appear, but new shoots from dracaena and croton are often cut off and re-rooted in sand.



**Cane Cutting**

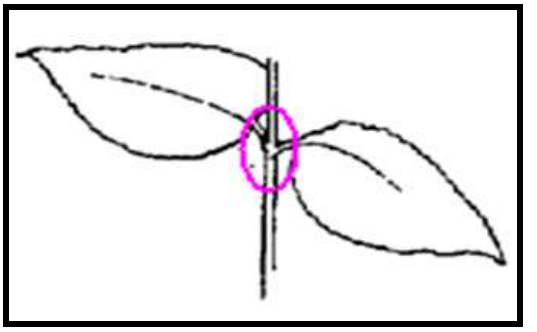
**Single Eye:** The eye refers to the node. This is used for plants with alternate leaves when space or stock materials are limited. Cut the stem about ½ inch above and ½ inch below a node. Place the cutting horizontally or vertically in the medium.



**Single Eye Cutting**

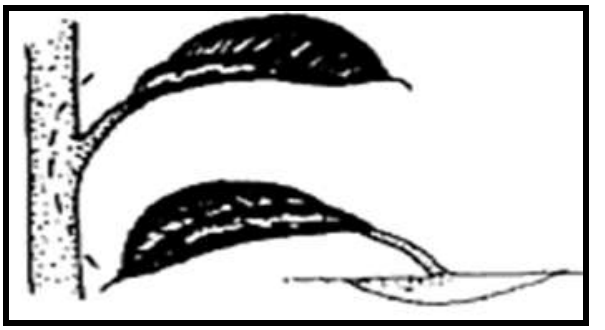
**Double Eye:** This is used for plants with opposite leaves when space or stock material

is limited. Cut the stem about ½ inch above and ½ inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.



**Double Eye Cutting**

**Heel Cutting**: This is an efficient method for stock material with woody stems. Make a shield shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.



**Heel Cutting**

**Leaf Cuttings**: Leaf cuttings are used almost exclusively for a few indoor plants. Leaves of most plants cannot be used for propagation.

**Whole leaf with Petiole:** Detach the leaf and 0.50 to 1.50 inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be cut off from the new plants when they have their own roots. The petiole can be reused.

**Whole Leaf with Petiole in Begonia sp.**

**Whole Leaf without Petiole:** This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will arise from the axillary bud. The leaf may be removed when the new plant has its own roots.

**Whole Leaf without Petiole**

**Leaf Sections:** This method is frequently used with snake plant and fibrous rooted begonias. Cut begonia leaves into wedges with at least one vein. Lay leaves flat on the medium. A new plant will grow at the vein. Cut snake plant leaves into 5cm sections. The lower cut is slanted and the upper cut to identify the top. Insert the cutting vertically. Roots will form fairly soon, and eventually a new plant will appear at the base of the cutting. These cuttings will rot if kept too moist.

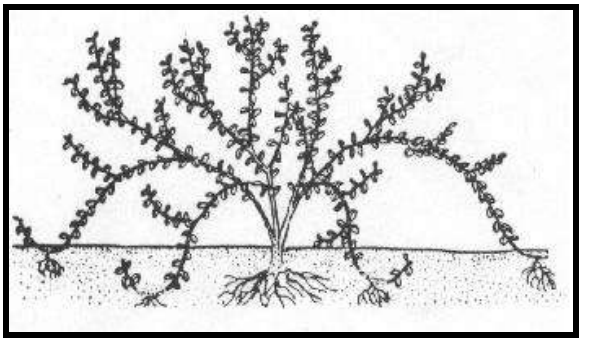
**Root Cuttings***:* Root cuttings are usually taken from 2 to 3 year old plants when they have a large carbohydrate supply in their dormant season. Root cuttings of some species produce new shoots that form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

**Plants with Large Roots:** First, make a straight top cut; then make a slanted cut 2 to 6 inches below the first cut. Store about 3 weeks in moist sawdust, peat moss or sand at 4° Celsius. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often done outdoors.

**Plants with Small Roots:** Take 1 to 2 inch sections of roots. Insert the cuttings horizontally about 0.50 inches below the surface of the medium. This method is usually done indoors.

**Layering**:

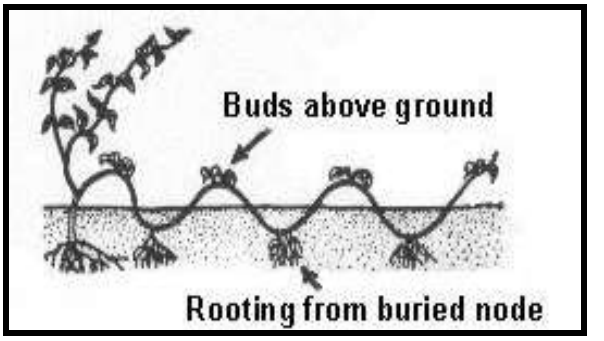
**Tip Layering:** Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend and the recurved tip becomes a new plant. Remove the tip layer and plant it in monsson. This method is successful with purple and black raspberries and trailing blackberries.



**Tip Layering**

**Simple Layering:** Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed. Bend the tip into a vertical position and stake in place. The sharp bend will often induce rooting, but wounding the lower side of the branch or loosening the bark by twisting the stem may help. This method is successful with plants like the Rhododendron and Honeysuckle.

**Compound Layering:** This method works for plants with flexible stems. Bend the stem to the rooting medium as with simple layering, but alternately cover and expose stem sections. Wound the lower side of the stem sections to be covered. This method is successful with heart-leaf philodendron and pothos.




**Compound Layering**

**Mound (Stool) Layering:** Cut the plant back to 1 inch above the ground in the dormant season. Mound soil over the emerging shoots in spring to enhance their rooting. This method is successful with gooseberries and apple rootstocks.

**Air layering**: Air layering is used to propagate some indoor plants with thick stems or to rejuvenate them when they become leggy. Slit the stem just below a node. Surround the wound with wet sphagnum moss. Wrap plastic paper around the sphagnum moss and tie it in place. When roots are penetrate the moss, cut the plant off below the root ball. Use this method for croton, rubber tree etc.

**Grafting:**

**Cleft Grafting**: Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree. Collect scion pieces 3 to 5 inches long that have one or two buds. Cut the limb or small tree trunk to be reworked perpendicular to its length. Make a 2 inch vertical cut through the center of the previous cut, being careful not to tear the bark

and keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3 to 4 inches long and insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with plastic paper.

**Bark Grafting**: Bark grafting can be used on large limbs. Collect scion wood about 0.50 inches in diameter when the plant is dormant; store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock at a right angle to itself. In Monsoon when the bark is easy to separate from the wood, make a 0.50 inch diagonal cut on one side of the scion and a 1.50 inch diagonal cut on the other side. Leave two buds above the longer cut. Make a cut a little wider than the scion through the bark of the stock and remove the top third of the bark from this cut. Insert the scion with the longer cut against the wood and nail the graft in place with flat headed wire nails. Cover all wounds with aluminum foil and clear polyethylene plastic.

**Whip or Tongue Grafting**: This method is often used for material 0.25 to 0.50 inch in diameter. The scion and rootstock is usually the same diameter, but the scion may be narrower than the stock. This strong graft heals quickly and provides excellent cambial contact. Make a single 2.50 inch sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface, slice downward into the stock and upward into the scion so the pieces will interlock. Fit the pieces together; then tie and wax the union.

**Care of the Graft**

Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material, such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts in order to prevent girdling and death of the graft. Rubber budding strips have some advantages over other materials because they expand with growth, do not usually need to be cut as they deteriorate and they break after a short time. It is also an excellent idea to inspect the grafts after a 2 to 3 week period. Limbs of the old variety that are not chosen for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually reduced as the new one increases until the new variety has completely taken over at the end of 1 or 2 years. Complete removal of all the limbs of the old variety at the time of grafting increases the shock to the tree and causes excessive suckering. In addition, the scions may grow too fast, making them susceptible to wind damage.

**Budding**

**Patch Budding**: Remove a rectangular piece of bark from the rootstock. Cover this wound with a bud and matching piece of bark from the scion. If the bark of the rootstock is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped the patch will be held firmly in place.

**Chip Budding:** Slice downward into the rootstock at a 45° angle through 0.25 inch of the wood. Make a second cut about 1 inch long upward from the first cut. Remove a

bud and attending chip of bark and wood from the scion, shaped so that it fits the rootstock wound. Fit the bud chip to the stock and wrap the union with a polythene strip.

**T-Budding**: When the bark is slipping, make a vertical cut through the bark of the rootstock while avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T- shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, some bark and a thin section of wood. Push the shield under the loosened stock bark and wrap the union, leaving the bud exposed.

### *2. Sexual Plant Propagation*

Plants can also be propagated using sexual propagation. Sexual propagation involves the union of the pollen from the male plant with the egg from the female plant in order to produce a seed. When a seed matures and is put in a favorable environment, it will germinate and begin active growth.

### Seed Germination

To obtain quality plants, start with good quality seed from a reliable dealer. Choose varieties adapted to your area and make selections based on desired size, color and habit of growth.

**Environmental Factors Affecting Germination**: Four environmental factors affect germination. These include water, oxygen, light and heat.

**Water:** The first step in the germination process is the absorption of water. Even though seeds have great absorbing power, due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water.

**Light:** The light reaction is a complex process that may either stimulate or inhibit seed germination. Plants requiring light for seed germination are Ageratum, Begonia, Browallia, Impatiens, Lettuce and Petunia. Conversely, Calendula, Centaurea, Pansy, annual Phlox, Verbena and Vinca germinate best in the dark.

**Oxygen:** Respiration takes place in all viable seed. In non-germinating seed, respiration is low but some oxygen is still required. The respiration rate increases during germination therefore the medium in which the seed is placed should be loose and well aerated.

**Heat:** It not only affects the germination percentage but it also influences the rate of germination. Some seeds will germinate over a wide range of temperatures, whereas others require a narrow range. Many seeds have minimum, maximum and optimum temperatures for germination.

### Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, dormancy is difficult to break even when the environment is ideal. Various treatments are performed on the seed

to break dormancy and begin germination as follows:

**Seed Scarification**

Scratching or softening the seed coat so that water can enter and germination can begin is known as seed scarification. There are several methods of scarifying seeds. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid at about twice the volume of seed. The seeds are gently stirred and allowed to soak from 10 minutes to several hours depending on the hardness of the seed coat. Another scarification method is mechanical. Seeds are filed with a metal file, rubbed with sandpaper or cracked with a hammer to weaken the seed coat prior to planting. Seed scarification can also be accomplished using hot water; the seeds are left to soak in the water as it cools for 12 to 24 hours before planting. A fourth method involves storing seeds in a non-sterile, warm, damp container where the seed coat will be broken down by decay over several months.

**Seed Stratification**

Seeds of some trees and shrubs of the temperate zone will not germinate unless chilled underground as they overwinter. The sphagnum moss is thoroughly wetted and excess water is squeezed out. Mix seed with the sphagnum moss or peat and place in a plastic bag. Use a twist tie or rubber band to secure the top and put the bag in a refrigerator. Temperatures ranging from 2° to 7° Celsius are effective and most refrigerators operate in this range. Check the bag periodically; if there is condensation on the inside of the bag, the process will probably be a success. After 10 to 12 weeks, remove the bag from the refrigerator and plant the seeds in pots to germinate and grow. Handle the seeds carefully as small roots and shoots may be emerging at the end of the stratification period and care must be taken not to break these off.

**Sowing the Seeds**

**Media:** A wide range of materials can be used to growing seeds, from vermiculite or mixtures of soilless artificial media to the various amended soil mixes. The medium should be rather fine and uniform, yet well-aerated and loose. It should be free of insects, disease organisms and weed seeds. It should also be low in fertility, low in soluble salts, and capable of holding and moving moisture by capillary action. One medium with these qualities is a combination of one-third sterilized soil, one-third sand or vermiculite or perlite, and one-third peat moss. The importance of using a sterile medium and container cannot be over emphasized. Sterilization of media should prevent damping-off and other plant diseases it should also eliminate potential plant pests. Wood or plastic growing containers and implements should be washed to remove any debris. Avoid recontamination of the medium and tools.

**Containers:** Wooden or plastic flats and trays can be purchased of a convenient size that is about 12 to 18 inches long, 12 inches wide and about 2 inches deep. Leave cracks about 0.13 inch between the boards in the bottom or drill a series of holes for adequate drainage. Flower pots of clay or plastic can also be used. Plastic bags are also available in

various sizes.

**Seeding:** The proper time to sow seeds for transplants depends on when plants can be safely moved out-of-doors area. After selecting a container, fill it to 0.75 inch from the top with the moistened medium you have chosen. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if they require darkness for germination. A suitable planting depth is usually about twice the diameter of the seed.

**Seed Tape:** Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-to-handle seeds. However, tapes are much more expensive with respect to the seed. The tapes can be cut at any point for multiple row plantings, and thinning is rarely necessary.

**Watering:** After the seed has been sown, thoroughly moisten the planting mix. Use a fine mist spray or place the containers in a pan or tray with an inch of warm water in the bottom. Avoid splashing or excessive flooding, which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.

**Transplanting and Handling Seedlings**

If plants have not been seeded in individual containers, they must be transplanted to give them proper growing space. The ideal time to transplant young seedlings is when they are small and there is little danger from setback. This is usually about the time the first true leaves appear above or between the cotyledon leaves. Do not let plants get hard and stunted or too tall and leggy.

Seedling growing mixes and containers prepared by methods similar to those mentioned for germinating seed. However, the medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble house plant fertilizer at the dilution recommended by the manufacturer about every two weeks after the seedlings are established.

To transplant, carefully dig the small plants up with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Avoid tearing roots in the process. Handle small seedlings by the leaves, not the delicate stems. Punch a hole in the medium into which the seedling will be planted. Make the hole the same depth that the seedling was growing in the seed flat. After planting, firm the soil and water gently. Keep newly transplanted seedlings away from direct heat in the shade for a few days or place them under fluorescent lights. Continue watering and fertilizing as was done in the seed flats.

**Hardening Plants:**

Hardening is the process of altering the quality of plant growth to withstand changes in environmental conditions that occur when plants are transferred from a greenhouse or home to the garden. A severe retardation in growth may occur if plants produced in the home are planted outdoors without undergoing a transition period. Hardening is less

critical for crops planted later in the season than for early crops when adverse climatic conditions can be expected. Hardening is accomplished by gradually lowering temperatures and relative humidity while also reducing water. This results in an accumulation of carbohydrates and a thickening of cell walls. The change from a soft, succulent type of growth to a firmer, harder type of growth is desired. Hardening should be started at least two weeks before planting in the garden. When put outdoors, plants should be shaded and then gradually moved into sunlight by increasing the length of exposure each day. After proper hardening, however, they can be planted outdoors as bright light will not damage them.

## 8.2.4 Nursery Plant Exhibition and Marketing

**Nursery Plant Exhibition**

Exhibiting plants in shows and fairs can be fun. Costumers will enjoy nursery plant when nurseryman displays them at exhibition stall or at community events. Nurseryman can learn by exhibiting. Others can learn by sharing knowledge and experiences with them and observing the exhibiting skills.

**While Exhibiting the Nursery Plants**

**Color:** The color should be vivid and bright, whether it is a dark shade or a pastel. Fading colors on petals or on leaf due to over maturity is undesirable. Foliage color should be typical of the plant type, whether dark green or variegated.

**Condition:** The condition of a plant or flower is based on the appearance of the specimen. For the condition criteria, mechanical injury, bruising, immaturity, age and weather damage should be considered undesirable.

**Cultural Perfection:** Cultural perfection is a criterion use to evaluate the cultural techniques used in growing a flower or plant. Proper fertilization, watering, pest control, disbudding, dividing, removal of spent blooms and quality of potting soil are cultural techniques that are evident in the appearance of flowers or plants.

**Form:** The shape is the true or characteristic form of a plant. Poor form may result from mechanical injury, insect and disease damage, or poor cultural practices.

**Grooming:** Clean plants to remove dirt and residues, as well as dead foliage or flowers. Grooming should not alter the typical features on the plants.

**Size:** The size of a plant should be as large as the variety allows under proper growing conditions. The stem and foliage should be proportional to the bloom size. Large blooms are not desirable if they are poor in condition or form.

**Stem and Foliage:** The stem supporting the blooms should be strong and in proportion to the plant. The leaves should be in good condition and in proportional size to the bloom and stem.

**Substance:** The material of which the plant is made should be strong, firm, crisp, and fresh. Over maturity often brings about a lack of substance, wilting, or thinning at the petal edges.

**Symmetry:** Beauty in a plant escalates due to a balanced proportion of parts on a plant.

**Plant Exhibition:** A nursery plant exhibition is organized to promote skill and knowledge of traditional methods of plant raising. At the same time it intends to improve knowledge of indigenous nurserymen and campaign amongst the private and government sector nursery for promoting tree plantation using tall trees, green foliage, and exotic plants to grasses.

Plants for exhibitions come in many varieties. Green-leaf plants for exhibitions and large trees, such as Ficus, Palm or Olive Trees are perfect for large areas and can be made the focal point of any exhibition space with dramatic lighting or simply planting them in containers. They look elegant and graceful and can be an eye catcher for exhibition attendees. Ferns and other smaller plants can be filled around them. Flowering containers, potted plants or arrangements of cut flowers are also available. Blooming plants will soften any space and make the area bright and cheerful. More exotic plants such as Hibiscus, Bromeliads or Azaleas can be used to create a custom look designed to draw attention to whatever product you may be exhibiting. Plants will draw attention and make exhibiting space much more inviting, resulting in more leads and possible higher sales.

**Flower Shows:** The primary objective of flower show is to create interest among the general public to grow quality flowers and maintain beautiful gardens in and around their houses. The display of quality exhibits inculcates the spirit of healthy competition among the participants. Flower shows give an opportunity to the people to know the wide range of plants that can be grown in the locality. The other advantage is that a visitor gets a chance to see all the best materials at a time in one place. A flower show should be a place for discussing the various garden problems, availability of nursery plants and to find out ways for solving each other's difficulties. Each participant should share his knowledge and experience with others. But unfortunately, due to professional jealousy people sometimes do not want to share their secret to success. It is also an occasion to demonstrate how a perfect exhibit can be grown. Besides all these, the aesthetic value of a show cannot be overlooked flower vases, bamboo stakes, show passes, benches and tables for exhibit should be made available to the participants. Arrangements should be made to open refreshment stalls. Nurserymen, seedsmen, companies selling agricultural implements, chemicals, etc. should be allowed to open their stalls on rental basis. Different educative charts on horticulture nursery should be displayed and demonstration on some horticultural nursery operations such as budding, grafting, pruning, etc. should also be arranged. A film Show on flowers, nursery and gardens, preferably in color, could be arranged in the evening accompanied by a supporting talk. Many flower show committees also make arrangements for bringing in exotic exhibits from abroad.

**Tips to Exhibitor:** The first and foremost thing is to get a schedule of the flower show well in advance and to convince oneself of the requirements. For example, roses are grouped into several classes for show purposes, such as Hybrid Tea, Floribunda, etc. and one has to exhibit the right type of rose in the appropriate class. Similarly, it may be specified that the annuals are to be displayed in groups of 6, 12, or 18 pots in as many different varieties.

After going through the schedule it has to be decided in which groups the entries are to be made. Once the decision is made the plants are raised accordingly and seeds of

flowering annuals procured. It is to be remembered that only best quality seeds can earn a prize and so the seeds are to be purchased from reputable nurseries or seedsmen at least a fortnight ahead of the sowing date. The sowing is to be staggered at intervals of 4-7 days so as to avoid disappointment as a result of casualty when planted in one lot. One more reason for staggering the sowing dates is to ensure that at least one group of plants is in perfect condition during the show time, as it may so happen that one group from a particular sowing date may fail to open the flowers on the scheduled date due to climatic or other reasons.

The plants for exhibition needs extra feeding with liquid manure but not over feeding, from the date flower buds start to appear. To obtain large flowers all auxiliary buds in flowers such as Carnation, Marigold, Dahlia, etc. should be disbudded as soon as they appear leaving only the apical bud to bloom the seasonal flowers or any other plant should be grown in the appropriate sized pot and not in an under or over sized pot. To make the plants bushy pinching should start at an early date for flowers such as *Brachycome, Carnation*, Marigold, *Zinnia* etc., and the operation repeated frequently, especially for Brachycome, Candytuft, *Petunia, Schizanthus*, French Marigold, etc. Only one annual should be grown in a pot. In some shows it is often seen that 3-4 seedling are grown in one pot to obtain a compact effect. This is absolutely not needed if the proper size of pot is selected and proper cultural procedure is followed. Some annuals such as *Zinnia* develop flower buds at a very early stage of growth which should be removed constantly until the plants attain sufficient vegetative growth. Some extra pots are to be raised than required as per schedule as few plants may die or fail to bloom on the appropriate date. If annuals are first grown in ground and then transplanted in pots, the operation should be under taken at least one month before the date of show to enable the plants to spread their roots end overcome the transplanting shock.

One should not try to hoodwink the judges by lifting ground-grown plants in pots a few days ahead of the show. Before displaying, the pots are to be cleaned properly or lightly painted with terracotta red (geru). No plants; either annuals or foliage, should be displayed in a crowded fashion. The Judges will like to see the plants individually and will also see the foliage. The foliage and other perennial plants such as *Bougainvillea* and *Hibiscus* are also grown in a similar fashion. They should be fed with liquid manure prepared from oil cake once in a fortnight or 20 days. The leaves should be washed regularly by spraying.

**Precautions:** A few extra plants are to be taken to the show than required as plants may get damaged while in transit. The branches should be staked properly during transportation to prevent damage. Some sort of staking is permitted in shows for certain category of plants but this, should not be obtrusive. During transit delicate flowers may be covered with tissue paper as a precaution against being bruised. Often plants get stolen from shows and one should do well to keep a vigil on his exhibits. Identification mark should be put on the pots, but this should not show prominently.

**Commercial Display in Nursery**

The display area should be separately from the production area because it will contain potting soil, equipment and chemicals. A display area located close to the office and containing a representative display of saleable plant materials, enables customers to view saleable plant material without traveling through the nursery. This saves time for customers and sales personnel. The display area should have tiered shelving for smaller plant display with the top shelves easily reachable and area with covered ground for larger plants and shrubs. The ground under larger plants must be covered to prevent weeds from growing around the merchandise and to stop insects and diseases from entering the planting pots. Also, pathways must be provided and designed in a way that customers can pull the product without interfering with customer traffic and there are no dead ends. The ground should be a hard surface such as brick or concrete so that you can keep it free of mud and dirt with brooms after watering your plants. Keep all plants according to their growing habits like perennial, annual, tree, shrub, herb, hedges, edge, bush, vine, fruit, vegetable, flowers, medicinal and aromatic, potted, indoor plant, etc. This can give an organized approach to the nursery and one can easily direct the customers to the right section.

**Marketing of Nursery Plants**

Marketing is planning and organizing the systems in such a way that will make consumers believe that they are buying something special, meets their needs and also supplying the right amount of product when the customers want to buy it. Customer perceptions are not just about price and quality, but may also include status, enjoyment, attractiveness, convenience, health. Producers should decide which factors are special for their product and emphasis these in their promotion.

**Direct Marketing**

This is sales by the nurseryman direct to the consumer. Different studies show that many consumers prefer direct contact with the nurseryman/seller compared to an impersonal service, although the latter are in some cases more efficient. One of the main advantages of direct sales to consumers is the opportunity to reduce marketing costs and to add value to the product so as to increase the profit margin. Nurseryman need to be aware of existing marketing tools in order to maximize sales.

**Retail Outlet**

In most cities municipal ordinances regulate places and areas where nursery plant retail outlets operate. In selecting a location the three main factors to consider are: good visibility, accessibility and proximity to buyers. Street or road crossings, the proximity of shopping centers or any other area which has the potential for high volume of customer traffic are good locations for produce sales outlets. Some municipalities give permission to place exhibits on sidewalks to attract customers provided they do not interfere with normal pedestrian traffic.

**Street Selling**

Although this method of marketing is frequently seen in developing countries like India, selling and peddling is generally not allowed by most municipalities. There are many reasons for this. There are public health security considerations, as this activity generates foul odour as well as insect and rodent proliferation. The second reason is that it constitutes unfair competition for established outlets. These are periodically inspected and are liable to taxes on their operations. Ambulatory selling is undertaken in vehicles either drawn by motor, animal power or humans and plants is peddled from home to home. Street selling has the same characteristics and limitations as ambulatory selling. As scales are unavailable, plants is generally sold by units.

**Nursery Markets**

A nursery market is a form of direct marketing that is located in or within proximity of a community where growers sell directly to numerous customers. Cash sales and the possibility of selling under or oversize units that cannot be marketed through other marketing channels are the main benefits of this system for nurseryman. For consumers it provides the opportunity to buy new plants and to interact with nurseryman in an informal environment. A nursery market becomes successful when here is cooperation and interaction among three key groups:

1. The sponsoring, organizing or promoting group may be a municipality a group of neighbors, the local Chamber of Commerce, a nurseryman organization or any other association or organized group.
2. Vendors are not only true nurserymen. They should also include backyard producers. This provides a means for them to increase their income.
3. It is estimated that one vendor can be supported by 800 potential buyers. So, a community of 8 000 residents could sustain a farmers market with 10 vendors.

The main advantages of selling at nursery markets include: minimum investment required for operating, there is no need for packaging materials, large volume of produce or a wide variety of products made available to the customers at one location.

**Regional Markets**

Regional markets exist in many developing countries where buyers and sellers meet to trade. From an organizational point of view they are very similar to nursery markets. One of the main differences is that operations; are more concerned with wholesaling, although some retailing is undertaken. A sponsoring organization also exists. Responsibilities include undertaking administrative duties of the market, one or more days per week for operating, stall rental on a daily basis, etc. This system provides many small-scale nurserymen with the opportunity to sell their plants at a fair price.

**Nursery Stall Sales**

Nursery outlets attract many customers. This form of direct marketing has the advantage of adding value. Location of the nursery outlet is extremely important because it has to be seen from a certain distance. It should be located on relatively busy roads. The main access routes to cities are probably the best places for these types of markets.

However, they can also be located in other areas such as tourist areas. Safe paved drives and availability of good parking space are factors to be considered.

There is no standard formula for designing a nursery outlet, as shelters, barns or special buildings may be used. They should be clean and tidy with enough space for displaying produce. A special type of farm sales is the "U-pick" or "pick-your-own" system. Consumers can choose and packaged plants on their own. In this type of nursery outlet, some plant has already been harvested and packaged. Sales are carried out in height, volume or units. The main benefit to the nurseryman with this form of direct marketing method is there is no need to harvest the plant. It also eliminates the need for sorting and packaging costs. This results in lower prices, making the plant more attractive to the consumer. The customer also has the opportunity of spending a day outdoors in contact with nature.

**Export of Nursery Plants**

Some exports require an export License before you can ship your plants. Some foreign countries have standards that you should be aware. There are some countries where one cannot sell plants. Use this section as a primer to familiarize yourself with the licenses, standards, and legal considerations that may apply to your plants.

**Export Licenses**

Learn when you need an Export License and from whom in order to ship your plants from India. Export licenses are issued for individual transactions determined by the product, the country, the end-use and the end-user.

**Foreign Standards and Certification Information**

Many foreign countries have their own standards and import certification requirements on things like: product standards, certification requirements, electricity regulations, packaging and recycling laws and quality expectations. If you want to sell your plants in foreign markets you should be aware of these Foreign Standards and Certification Requirements. When exporting, it is essential to be aware of the various regulations and Legal Considerations that pertain to your nursery plants.

## 8.2.5 Economics of Ornamental Plant Nursery

India ranks 28$^{th}$ in the ornamental plant production in the world. Ornamental plants produced in India include woody ornamentals (landscape trees and shrubs), foliage, flowering plant products, cut foliage and turfgrass sod. India dominates production of foliage plants. Growth of the ornamental plant industry in India has shown increasing sales annually.

**Seasonal Sales**

All industry groups generally followed similar trends, with peak sales during the Monsoon (June–October), followed by declining summertime sales. Flowering plant nurseries had dramatically more seasonal sales, with nearly 50 percent of annual sales during the monsoon and less than five percent monthly during the summer.

**Total Income**

Total income, including plant sales, changes in plant inventory values and miscellaneous income from brokerage services, interest on accounts, rents, etc.

**Resources Used and Resource Efficiency Indicators**

Resources used for nursery plant production were land, labor, and managed capital. Indicators of productivity, efficiency, and resource-use intensity express relationships between the use of productive resources (nursery growing space, labor, and capital) and monetary measures of output. Because of characteristic differences in resource use, these indicators are more meaningful for different types of nursery operation than for large or small businesses.

1. **Land:** Land used for plant production is measured as the average area in use at the beginning and end of the year. Net usable growing area included only space within growing beds and fields. Space in walkways, driveways, and other service areas were excluded. Growing area has increased day by day. Growing area varied dramatically among industry groups: woody container nurseries require more production area, while foliage nurseries averaged less area.
2. **Labor:** Labor used by nurseries was measured in terms of full-time equivalent (FTE) persons, including production, administrative, sales, and management personnel. In most cases, this was calculated by dividing total labor hours by 2,080 hours per worker per year (52 weeks in a year and 40 working hours per week).
3. **Capital Managed:** Total capital managed included both owned and leased assets in land, buildings, and equipment; and working capital in inventories, cash, and accounts receivable. Owned capital in buildings, improvements, and equipment were assessed at book value, while leased assets were taken at market value.
4. **Growing Area Managed per Worker:** The intensity of labor use was evaluated in terms of production area in acres per FTE person. Highly profitable firms had a significantly higher ratio of growing space to employees. Woody ornamental container and field nursery firms had a much higher ratio of growing space to labor while foliage and flowering plant firms averaged lower ratio of growing space to labor.
5. **Capital Managed per Worker:** The ratio of managed capital (owned plus leased) to number of FTE persons employed averaged more for large firms, and lower for small firms. Woody ornamental container and field nurseries had substantially higher capital-labor intensity, reflecting their greater mechanization and investment in land and plant inventory.
6. **Capital Managed per Acre***:* The ratio of capital managed to growing area (acres) varied, only marginally among large and small firms, but was significantly lower for highly profitable firms. Capital managed per acre was highest for foliage firms and lowest for woody ornamental container and field growers.

**Productivity Indicators**

1. **Value Produced per Square Foot:** The productivity of nursery space is measured by value of production per square foot of growing space. Foliage and flowering plant nurseries had significantly higher value per square foot because of their highly intensive production systems, while woody container and field firms have much lower values, and foliage growers were intermediate. Value produced per square foot is affected by nursery layout and space utilization efficiency, plant growth rates and survival, and inventory turnover.
2. **Value Produced per Worker:** Labor productivity was measured in terms of value produced per full-time equivalent (FTE) worker. Value per FTE worker averaged higher for large firms, and lower for small firms. Highly profitable firms had above-average labor productivity. Labor productivity varied among industry groups relatively less than other resource productivity measures. Woody container and field growers had values produced per worker is medium, foliage nurseries averaged is lower and flowering plant firms averaged more per FTE compared to each other. Variations in labor productivity may result from differences in investment for labor-saving equipment, labor management practices and practices affecting crop turnover.
3. **Plant Inventory Turnover:** This is an indicator of productivity that expresses the rate at which inventory is replaced on an ongoing basis, calculated as the ratio of annual sales to average inventory value. This measure accounts for the inherent value of different nursery crops. It can be interpreted as the number of crops per year. Inventory turnover is less for large firms, more for small firms. Inventory turnover generally has followed a pattern among industry groups similar to that for value produced per square foot high values for flowering plant and foliage nurseries, lower values for woody ornamental firms. Low inventory turnover is common for new and rapidly expanding firms because of large inventories of immature plants.
4. **Operating Expenses:** Operating expenses by nursery firms were grouped into the categories of management compensation, employee wages and benefits, supplies, facility and equipment, administrative and overhead, depreciation, and interest. Expenses for income taxes were not included in this analysis. Analysis of expenses in relation to the value of production is a reliable measure of cost efficiency that enables comparison of costs for different types of firms on a standardized basis. For each expense category, expenses were divided by total value of production.
5. **Management Compensation:** Salaries and benefits paid to owners and top management higher for large firms and lower for small firms. Management compensation has increased year by year. Management cost per-rupees value produced has decreased year by year. Because of economies of scale, differences in management cost efficiency among industry groups are mostly due to differences in average size of firms.
6. **Asset Turnover:** This indicator is analogous to inventory turnover except that it

expresses the ratio of annual sales to total assets. Asset turnover did not differ so widely among industry groups. In general, high asset turnover is desirable, indicating greater sales per rupee of investment. Low asset turnover rates may result from low labor or space productivity or excessive capital investment.

7. **Employee Wages and Benefits:** This is the largest expense category for ornamental plant nurseries. In addition to wages and salaries, this category included payroll taxes, workers compensation insurance, health insurance, bonuses, and other benefits paid. Labor costs were strongly related to profitability. By industry group, labor costs, as a share of value produced, were highest for foliage firms and lowest for field woody ornamentals growers.
8. **Supplies:** Direct expenses for supplies or "cost of goods sold" included expenses for plants and seeds, containers, peat and soil, fertilizer and lime, pesticides and chemicals, packaging materials, heating fuel, and other production supplies such as tags and small tools. Shrinkage in supply inventories is also included in this category but is an insignificant amount in all cases.
9. **Facility and Equipment:** Repairs and maintenance for nursery facilities and equipment operating costs (i.e. fuel) more for large firms and less for smaller nurseries. These expenses have increased day by day. Facility and equipment costs as a share of value produced averaged five percent for firms.
10. **Administrative and Overhead Costs:** This broad category included expenses for travel and entertainment, property insurance, telephone, electric power, advertising, property taxes and business licenses, rent, and other cash expenses (i.e. professional services, trade association memberships, office, and miscellaneous). These costs were similar for plant industry groups.
11. **Interest:** Interest expense for borrowed capital more for large firms and less for small firms. This expense item has increased more day by day, more than any other expense category. Interest expense, as a share of value produced, averaged 4 per cent in firms.
12. **Depreciation:** Depreciation is a non-cash allowance, representing the decreasing value of assets in buildings and equipment and is a cost of business over the long term. Depreciation is generally taken from company income tax returns and computed according to the ACRS method (3, 5, or 7 years) for equipment and straight-line or double declining balance methods (10 to 20 years) for buildings and constructions.
13. **Total Costs:** Total operating costs includes Supplies, Plants & seeds, Containers, Heating fuel, Growing media, Fertilizer/lime, Chemicals, Packaging, Other supplies, Facility & equipment, Facility repair/ maintenance, Vehicle & Equipment operation, Overhead, Travel & entertainment, Insurance, Telephone, Electric power, Taxes & licenses, Advertising, Rent, Other expenses, Depreciation allowance, Interest, etc.
14. **Cost per Square Foot:** The cost per unit of growing space is a useful measure for estimating individual plant growing costs or comparing cost efficiencies of different production systems. These results paralleled those for value of production per square foot and inventory turnover.

**Net Returns and Profitability**

1. **Net Firm Income:** Net firm income is the difference between total income and total costs less management and interest costs and excludes income taxes.
2. **Return to Capital:** Return to capital represents profits after management and interest expenses are deducted from net firm income, giving the net returns attributable to the capital investment.
3. **Net Margin:** Net margin is the ratio between net firm income and total income or, in other words, the share of total income that is net income.
4. **Rate of Return on Capital:** Rate of return on capital is the ratio of return to capital divided by net asset value. These results confirm that profitability in the nursery plant industry has continued to decline as the industry becomes more competitive.
5. **Rate of Return on Net Worth:** This is the most comprehensive measure of profitability, calculated by dividing return to capital by net worth to express returns in relation to the net assets owned and is comparable to annualized yields on stocks, bonds, or savings deposits. This measure takes into account the financial risk of the venture.
6. **Assets, Liabilities, and Net Worth**: Assets and liabilities were calculated, as an average of beginning and ending balance sheet.
7. **Assets:** Current assets, including cash on hand, accounts receivable, and plant and supply inventories. Plant inventories were the largest component of assets. Long-term assets include investments in buildings, machinery and land at book value.
8. **Liabilities:** Current liabilities, including accounts payable and other liabilities payable within one year; while long-term liabilities such as notes payable and mortgages.
9. **Net Worth:** Net worth or equity is the difference between total assets and total liabilities. It represents the value of the owners share of assets. Generally, leverage factors below 2.0 are considered to represent a very safe financial position. The impact of financial leverage on profitability can be understood as a multiplier (leverage multiplied by the rate of return to capital assets equals the rate of return on net worth). Since leverage is always greater than or equal to one, return on net worth is always greater than rate of return on capital assets, either positively or negatively.
10. **Financial Ratios:** Financial solvency and liquidity were evaluated with two financial ratios the quick ratio and the leverage ratio.
11. **Quick Ratio:** The quick ratio is a measure of a firm's ability to meet short-term debts. It is calculated by dividing cash and accounts receivable by current liabilities. Cash and accounts receivable are the most liquid of current assets, which are usually available on short notice, but inventories are not included in this measure because they may not be immediately salable. A value for this ratio below 1.0 would indicate an illiquid position.
12. **Leverage:** Financial leverage is the ratio of total assets to net worth and is an

indicator of long-term solvency. Higher values indicate greater risk, with potential for both greater returns and greater losses. There was no consistent trend in leverage with respect to firm size or profitability. Generally, leverage factors below 2.0 are considered to represent a very safe financial position. The impact of financial leverage on profitability can be understood as a multiplier (leverage multiplied by the rate of return to capital assets equals the rate of return on net worth). Since leverage is always greater than or equal to one, return on net worth is always greater than rate or return on capital assets, either positively or negatively.

## 8.3 Glossary

**Annual:** A plant in which the entire life cycle is normally completed in a single growing season.

**Asset:** An asset is a resource controlled by the entity as a result of past events and from which future economic benefits are expected to flow to the entity

**Demand:** It is the desire to own anything, the ability and willingness to pay for it.

**Depreciation:** Depreciation is the gradual and permanent decrease in the economic value of the capital stock of a firm, nation or other entity, either through physical depreciation, obsolescence or changes in the demand for the services of the capital in question.

**Income:** Income is the consumption and savings opportunity gained by an entity within a specified time frame, which is generally expressed in monetary terms.

**Interest:** Interest is a fees paid on borrowed assets. It is the price paid for the use of borrowed money or money earned on deposited funds.

**Labor:** Labour is a measure of the work done by human beings.

**Liability:** Liability is defined as an obligation of an entity arising from past transactions or events, the settlement of which may result in the transfer or use of assets, provision of services or other yielding of economic benefits in the future.

**Resource:** A resource is any physical or virtual entity of limited availability that needs to be consumed to obtain a benefit from it.

**Supply:** Supply is the amount of some product which is available to customers.

## 8.4 Points to Remember

- Ornamental trees are classified as flowering trees which bears flower and foliage or are shade trees which have a dense canopy.
- Shrubs are perennial plants with many woody branches. Climbers have weak stem and ability to climb on support.
- Edges are live plants small in height and hedges are tall in height and used continuous to obtain a screening effect.
- Cactus and succulents are able to withstand in dry and drought conditions.

- In Sexual propagation, seed germinate in favorable climatic resources like water, oxygen, light and heat.
- Exhibition plants facilitate the share culture, knowledge, skill, marketing, to create interest, competition etc.
- Marketing is putting systems in place, consumer buying something special and also supplying the right amount of product.

## 8.5 Self Check Questions

Q.1. Define ornamental plants and classify them with examples.
Q.2.Write short notes on Flower Exhibitions and Shows.
Q.4. Explain the marketing of ornamental nursery plants.
Q.5. Enlist the resources used in ornamental plant nursery.
Q.6.What is operating expenses in ornamental plant nursery.

## 8.6 Do It Your Self

- Identify and classify the native ornamental plants in your village.
- Analyze the demand and supply of ornamental plant in your city.
- Visit a Flower show, Flower arrangement Expo, ornamental plant exhibition and record the branding system of various plants and products.

# Unit 9: Plant Library Concepts and Operations

***Index***



## 9.1 Introduction

It is one of the important concepts to establish a plant library to emphasize the process and value of plants and collection of fascinating, important plants to all categories of people. Detailed notes on location, habitat, names of the collectors, etc. are also noted for references. The students, academicians, professionals and amateurs learn about the botanical and horticultural aspects such as names, important concepts of ecology of plants, characteristics, families etc. Relevant information is given regarding location along with sample. Systematic documentation of the plant includes selection of plants, institution, etc.

Plant library can be defined as exhaustive collection of plants and specimens in different forms preserved and placed to provide information about plants to beginners, professionals, academicians, students, nurserymen in a relevant way. It is a collection of plants from different sources and locations in a wide range of plant species with their botanical names, availability and basic information of the plant for variety of purposes including aesthetic value.

**At the end of this unit you will be able to know and understand:**

- Various groups of foliage plants for decoration in residential and public places.
- Care and maintenance techniques of the foliage plants.
- Collection, selection and preservation of various plants for aesthetic uses.
- Meaning and purpose of a Plant Library and the care and maintenance of the library plants.

## 9.2 Content

### 9.2.1 Selection and Preparation of Library Plants:

Plants are carefully selected according to their importance by specialist and faculties, students and professionals. The selection process is slightly different in each content area like Horticulture, Forestry, Botany etc. Identification of scholars and experts with relevant expertise and the definition of selection criteria are necessary. Identification of information sources for recommended plant material eg. Institutional collection, libraries, private collection and repository institutions should be done at the beginning.

Plant library is related with diverse group of people; hence advertisement of plant library is a key factor to reach to the target group. Without advertisement there can not be a professional achievement in the plant library business. It can be done by using different type of media. The electronic media can be used effectively to reach the customers. Nevertheless, leading newspapers, magazines, books etc. can also be used for publicity of the plant library project.

**Methods of Collection:**

**Live Plants**

This is a continuous process in which live plants are collected and maintained in the plant library. The plant of the utmost importance like the rare species, value added plants, and commercial plants are maintained in live collection.

**Herbarium**

A mini herbarium (dried plant library) is a collection of plant specimens with their nomenclature, habitat, name of the collector, utility and availability etc.

**Flashcards**

Flashcards are prepared with taping of pressed specimens or pictures from magazines on to index cards and labeling the cards with plant names .this can be the useful way to learn how to identify the plants.

**Photographs**

Photographing plants is another means to collect information and pictorial view of the plant for identification and preservation. The plants which are not available but have commercial importance can be collected by way of photographs either by institute itself or from another source. This can be the best way for the specimens which are at multi-location.

**Photocopies**

Photocopies of plants provide required details about the plant to get acquainted, collected information and reference. It is an easiest way to gather information for identification and guidance for use. The published sources of the plant are used for making the photocopies.

**Bibliography**

Preparation of bibliographies, list of priority material and collection of specimens for library are good source to have information on huge number of plants. This is an easy way of documentation.

**Digitization**

Computerized database of plants with photographs which enables ready to serve soft information convertible to visual source and greatest convenience for mobility of the material. It can be paperless source of which can be an international source of plant information without boundaries and universal applicability. This can be huge database from many countries and institutes.

**Planting**

Planting live plantlets provide an excellent opportunity to learn about plants over a period of time. Well drained light soils with good moisture retention are good for planting library plants. Planting should be done when soil is warm. To make soil more suitable and workable apply light water to the soil three hours prior to planting. Avoid over watering. To avoid stress planting should be done in late afternoon. Water stagnation results in root rot or susceptible to fungal diseases. Set plants in the ground at the same depth as they were in container.

## 9.2.2 Location Specific Library Plant Arrangement

**Climate**

Climate has direct effect on health and vigor of plant. The climate of the area is a permanent feature and cannot be changed. The climate and type of soil, rainfall, temperature, and humidity play an important role in sustainability of the plants. It influences the growth of the plants. Many plants are capable to grow in diversified climatic conditions but preference should be given to well growing local species.

**Plants Growing in Sunlight**

Selection of plants: Choose desirable plants for particular area. Select popular plants suitable for the region. The geographic location of that area is important consideration while selecting plants. The performance of plant differs from site to site and climatic conditions e.g. plains, tropics, temperate or coastal areas.

Some of the plants are very good in protecting environment and helps in bringing down pollution and maintain the balance of the nature. Some of the plants can tolerate extreme conditions.

**Annuals**

An annual is the plant which completes its life cycle in a single season. It grows from seed to flowering in a single season; they give quick effect and are short lived but bring fantastic colors. They are most commonly used in monsoon and summer. Some of the best growing annuals are marigold, aster, petunia, salvia, zinnia .larkspur and cosmos. They are grown by two ways by direct seeding and raising seedlings in the nursery and

transplanting in the field. When they are seeded it requires thinning. Hardy annuals can survive low temperatures and some light frost, while tender annuals cannot tolerate low temperatures during cold and should be planted only after there is no more danger of frost. Half-hardy annuals can tolerate some cold temperatures, but are usually killed by frost. Annuals make excellent space fillers for the perennial garden.

**Biennials**

The plants which complete their life cycle in two years are called as biennials. They complete their vegetative growth during first year and flowering or regenerative phase during second year. Although are not quite as permanent as perennials, many biennials re-seed themselves, becoming comparable in performance to perennials. Biennial seeds that are planted one year will not flower until the following year. Foxglove, Hollyhock and Iceland poppy are biennials.

**Perennials**

These are the most versatile plants. These are the plants which have life for more than two years. Generally they have life of three to four years few of them may extend their life for four to five years. Most of them have dormancy during winter and blooms during rest of the period. They are good border plants e.g. Dahlia and Perennial phlox. They are growing in many colors, shape, texture and scent. They are very popular as borders, interplants with annuals and foliage plants.

**Introduction of New Plants**

The plants which are introduced from exotic source or other locality are called as introduced plants. Some of the valued, novelty plants are being brought from the places where they are available. Many flowering annuals were introduced from Europe and America during British regime. The wild and cultivable plants of African origins were also introduced.

**Indoors**

The plants can be raised in shade like, corridors, verandah, windows, balconies, patios, conservatories, and indoors. The choice of the plant depends upon the interest and purpose of the collection. They grow well either in shade or semi shade with filtered light. Some of them grow well in full shade. Some indoor plants need 4 to 6 hours of sunlight either in the morning or evening.

**Bulbs**

This class of plant consists of true bulbs, corms, rhizomes, tubers and tuberous roots.

- True bulbs have an internal flower bud surrounded by layers of food supply.
- Corms are stored food, which consists of roots at the base and small buds at the top. Crocus and gladiolus are examples of corms.
- Tubers are the round food-storing part of a stem and flowers are developed within them. Tuberous roots are the food storing part of roots. Dahlia and tuberous begonias are produced from tuberous roots.
- Rhizomes are similar to tubers, but they are long.

Hardy bulbs can sustain in the ground throughout the winter months. In the extreme cold months, bulbs benefit from a layer of winter mulch. Some summer bulbs do not survive freezing temperatures. It is thus necessary to dig them up and store them in a warmer area. Once the foliage has yellowed, the bulbs are dug out and separated, the soil is brushed off and the foliage is cut approximately 10-15 cm above the bulb. Damaged and diseased bulbs should be discarded. Lay the bulbs out on a screen or newspaper to dry for a few days. Layer the bulbs in a mesh bag or any ventilated container. Place the bag where the temperature is around $10^{o}$ Celsius. Periodically check the bulbs. In the summer, they can be planted back in the garden.

**Preparation of Soil Media**

A soil test is recommended to determine the type of soil of the area. The test will help in determining the plants most suitable for the respective area and will also indicate the nutrients which would be required to be supplied from outside. The test will indicate the pH level in the soil (alkaline or acidic) as well as levels of nutrients and minerals. Soil to be tested must be collected from several spots in the garden. Holes dug are 6-8 inches deep.

It is important to improve the soil conditions to help plants grow faster, become stronger and healthier, and establish faster in field. The simplest way to improve the soil condition is to add organic material. Well decomposed material is very effective in improving the soil conditions. Organic manure must also be added into the soil before planting. For proper root development, approximately 1 to 2 feet of the soil should be loosened and all large clumps should be removed. The area should be free of weeds.

**Location Specific Plants for Institutions**

The scholars and professionals working in the professional, academic and educational sections of various institutions need information on various types of plants for different reasons. These people have specific interests viz. horticultural, ornamental, botanical, forestry etc. The instructional farms are planted with cafeteria to educate the students about plants and their identification, commercial use, etc. The utility of the plant depends upon the discipline of the graduate. The collection of plants is made accordingly and maintained in a good condition to meet the requirement of the target group. It is always diversified but defined set of plants to be explored for institutes.

**Plants for Public Places**

The public places have open place which is used for avenue plants and parks. Cities are becoming congested and public parks are created in the cities for recreation. It is also done to beautify the locality and bring down the pollution in the area. The open space is utilized to conserve nature by massive tree plantation. The public places are bus stand, railway stations, court premises, magistrate office, council hall, district and state headquarters, stadiums etc.

**Commercial Places and Corporate Offices**

The national growth rate of India is 8-9%. With the increase in industrial towns and multinational companies in IT sector huge network of corporate offices have

mushroomed. All these establishments are very particular about the look of their premises. The beatification of the premises is done with the help of gardens and landscapes. This has created the demand for exclusive ornamental plants of aesthetic value. The outdoor and indoor plants are used in beautification of the corporate offices and their premises. This not only gives a classy look but also creates a favorable working atmosphere. Many exotic plants are introduced for gardens of corporate offices.

**Hotels**

Hotels are the commercial places to run for the business of hospitality and accommodation. They have been categorized as per the grade. The star hotels are places for high profile executives, industrialists and heads of the states. They have exclusive gardens and indoors of utmost beauty. The most exclusive plants are used for this purpose. The hotel industry is growing many folds. Even medium grade hotels maintain best possible gardens to attract the high class customer.

The beautiful garden needs diversified plants and trees. It is combination of all types of plants such as annuals, biennials, perennials, shrubs, bushes, climbers, foliage plants etc. Hotel gardens also reserve area for children with addition of few birds and pet animals.

**Valued Plants**

Some plants are highly valuable due their utility in herbal medicines, cosmetics and culinary uses. The content of the plants enables premium value for them. They are having aesthetic as well as commercial value. Some plants contain essential oil which is used for making cosmetics, perfumes and scented medicines. They are also used in aroma therapy.

**Indoor Plants**

| Sr. | Common name | Botanical name | Propagation Method |
|---|---|---|---|
| 1 | Green aglonema | *Aglaonema commutatum* | Suckers, cutting |
| 2 | Yellow white stupped Aglaonema | *Aglaonema hospitum vr. Variegatum* | Suckers, cuttings |
| 3 | Alocacia | *Alocasia amazonica* | Bulbs |
| 4 | Pineapple ananas (ornamental) | *Ananas comosus* | Crans |
| 5 | Anthurium | *Anthurium andreanum* | Bulbs, suckers |
| 6 | Aphelandra | *Aphelandra roezlii* | Suckers |
| 7 | Aralia | *Aralia balfouriana* | Soft hard wood cutting |
| 8 | Asparagus | *Asparagus densiflorus* | Soft hard wood cutting |
| 9 | Aspidistra | *Aspidistra lurida* | Suckers |
| 10 | Bignonia | *Begonia maculata* | Soft wood cutting |
| 11 | Caladium bulb | *Caladium sp.* | Suckers |
| 12 | Chlorophytum ribbongrass | *Chlorophytum comosum* | Soft hard wood cutting |

| Sr. | Common name | Botanical name | Propagation Method |
|---|---|---|---|
| 13 | Croton | *Dodiaeum variagata* | Soft wood cutting |
| 14 | Dracaena (green yellow) | *Dracaena reflexa* | Tip cutting, soft hard wood cutting |
| 15 | Cordyline dracaena | *Dracaena cordyline* | Tip cutting |
| 16 | Cuphea | *Cuphea rosea* | Soft wood cutting |
| 17 | Diffenbachia | *Diffenbachia picta* | Soft hard wood cutting |
| 18 | Eranthemum | *Eranthemum nervosum* | Soft hard wood cutting |
| 19 | Rubber plant | *Ficus elastica* | Hard wood cutting |
| 20 | Fittonia | *Fittonia argyroneura* | Seed |
| 21 | Helicornia | *Heliconia angustifolia* | Suckers |
| 22 | Pernial impatiens | *Impatiens balsamina* | Soft wood cutting |
| 23 | Iresine | *Iresine sp.* | Soft wood cutting |
| 24 | Maranta | *Maranta sp.* | Suckers |
| 25 | Monstera | *Monstera deliciosa* | Soft hard wood cutting |
| 26 | Panax | *Panax sp.* | Soft hard wood cutting |
| 27 | Pandanus | *Pandanus veitchii* | Various suckers |
| 28 | | *Peperomia sp.* | Leaf cutting |
| 29 | Geranium | *Pelargonium peltatum* | Seed / soft hard wood cutting |
| 30 | Philodendron | *Philodendron andreanum* | Soft hard wood cutting |
| 31 | Money plant ,Pothos sp. | *Scindapsus aureus* | Soft hard wood cutting |
| 32 | Ruscus | *Ruscus hypoglossum* | Cutting, suckers |
| 33 | Bird of paradise | *Strelitzia reginae* | Suckers |
| 34 | Syngonium | *Syngonium podophyllum* | Suckers |
| 35 | Painted inch | *Tradescantia spp.* | Soft wood cutting |
| 36 | Zebrsna pendual | *Zebrina pendula* | Soft hard wood cutting |
| 37 | Fern | *Polypodium sp.* | Suckers |
| 38 | Acalypha | *Acalypha wilkesiana* | Soft hard wood cutting |
| 39 | Pilea | *Pilea muscosa* | Soft wood cutting |
| 40 | Thuja morpankhi | *Thuja compacta* | Seed air layering |
| 41 | Rhoeo (Nurgis eye) | *Rhoeo spathacea* | Soft wood cutting sucker |
| 42 | Sansiviera (Mother-in-law's tongue) | *Sansevieria trifasciata* | Sucker, leaf |

## 9.2.3 Library Plants Transport and Handling

**Transport of Library Plants**

Plants are transported bare rooted either with wrapping of sphagnum moss or other water holding material. Thus the plants can be transported easily with less volume. This

method is followed when the plants have to be transported over a short distance and would require less than 24 hours for transportation.

For longer distances, plants are transported in cool vans. Now-a-days, plants are raised in plastic trays or small cones, pots etc. It is the most convenient, easy method to raise plants. They are packed in cardboard boxes to protect from damage during transportation. It is the most secure method of transporting plants without damage. All details of the plant type, name, manufacturer, purchaser and minor details as the up side of the box is marked to avoid damage to the plants.

Thermocol is extensively used as cushion material in packing .The plants are transported by air cargo as well as by ship in air-condition. This keeps plants in good condition and desiccation is avoided. The plants raised in container are of good quality and can be planted at any time but the cost incurred is more than other type of plants.

## 9.2.4 Cares and Maintenance of Library Plants

### Care of Live Plants

The plants are to be protected from all kind of stress like scorching sun, water scarcity, water logging, etc. It is necessary to maintain the optimum conditions for growth and development. They can be maintained in the best condition by following way.

### Weeding

Many weeds grow in plantations and compete with plants for nutrients and moisture. The main source of weeds is through contaminated manure and self seeding of weeds in the plantation. One must be very careful to keep area weed free. It can be done manually or by use of herbicides.

### Watering

Most of the plants need water for growth. The type of plant, soil, season and location decide the requirement of the plant. In early stage of growth plant needs little but frequent watering. The quality of water is also important. It should be free of salts, carbonates and bicarbonates.

The best time to apply water is during morning, this minimizes evaporation. Watering during night may promote diseases. It is important that water applied must reach the root zone. Light watering encourages the plant roots to grow near the surface of the soil.

Newly transplanted plants must be watered when the when the first two inches of soil dry out. Annuals may be watered more frequently than perennials as their root system is not well established. Over watering the plants must be avoided as it results into severe attack of fungal diseases.

### Fertilizing and Plant Feed

Organic manures are usually applied at the time of planting. They are mixed with media in addition to chemical fertilizers to supplement the requirement of nutrients.

There are four main nutrients that are most likely to be a problem in the soil: nitrogen, phosphorus, potassium, and calcium. The first three nutrients are found in most mixed fertilizers, and calcium can be applied separately.

- **Nitrogen** is necessary for new cell formation in all parts of a plant. Compared to other nutrients, nitrogen is typically the most lacking. A symptom of a shortage of nitrogen is yellow-green stunted growth.
- **Phosphorus** is necessary for development of roots and stems. This nutrient also stimulates fruit and seed production. A symptom of Phosphorus deficiency is red or purple discoloration of leaves. Because phosphorus gets fixed to soil particles, it is important to place it close to the roots.
- **Potassium** (potash) is necessary for strong roots, stem development and deep flower color. A symptom of potash deficiency is weak stems and yellowing or browning leaf tips and edges.

Fertilizer should be water soluble to be available to the plant soon after application. The organic nutrient sources such as compost, manure, bone meal, and blood meal are not readily available to plants. These materials must be broken-down before they are available to the plants. This makes them slow acting fertilizers. The nutrients of inorganic plant foods are in soluble form, which are readily available to plants. Inorganic plant feeds are not long lasting; therefore, frequent fertilizing may cause the chemicals to destroy the plant. If applied direct contact with foliage and roots must be avoided as it may damage or even kill the plant.

The percentage of nutrients is indicated on the fertilizer container. An inorganic fertilizer labeled as 20-20-20 indicates equal portions of nitrogen, phosphorus and potash and typically used in gardens with little nutrient deficiencies. Due to the difference between organic and inorganic plant feeds, a combination of the two may produce the best results.

- Liquid or water soluble fertilizers are good for accurate applications for container plants.
- Slow release fertilizers feed plants for an extended period of time, which is good for lawns and perennial plants.
- Limestone (calcium) neutralizes the acid level in soil.
- Side dressing adds fertilizer to plants during the growing period. Apply the fertilizer on top of the soil at least six inches away from the stem of the plant.
- Base feeding is especially good for shrubs and roses. Apply fertilizer on top of the soil at least six inches from the base of the plant and extend to approximately twelve inches beyond the branch tips. Scratch the fertilizer into the soil without disturbing the roots.

**Fertilizer Requirements**

| Plant Type | When to Feed | Remarks |
|---|---|---|
| Annuals | Before planting | Spread manures and fertilizer before turning soil. Feed again when plants are branching. |
| Bulbs | Early summer | Add fertilizer to planting hole. Cover it with a light layer of soil so bulbs are not placed directly on top of fertilizer. |
| Evergreens | Early summer | If pruned, feed again in monsoon. |
| Fruit Trees | Monsoon | Supplement with nitrogen at commencement of monsoon in addition to annual feeding. |
| Hedges | Monsoon | If pruned, feed again at start of monsoon. |
| Perennials | When new growth appears | Feed again when flower appear. |
| Roses | Spring and summer | Do not feed in winter as newly encouraged growth may be damaged by cold weather. |
| Shrubs | Monsoon | For mature plants, one feed per year. |
| Trees | Monsoon | Feed again in monsoon. |
| Tubers | Monsoon & September | Cover fertilizer with a light layer of soil so tubers are not coming directly on top of food. |
| Vines | Monsoon & September | Apply fertilizers in monsoon. |

**Potting**

Pot the plants in Loam and compost mixture, many plants perform very well in containers. Most of them are ornamental plants. Select right type of container and fill it correctly. Place broken pieces of bricks, gravel or coarse sand on the drainage hole. Add 2.5 cm draining layer of sand and mixed soil on it .The small containers are filled with peat moss or Coco peat. Water the plants carefully and regularly during early stages of development. The sun light requirement of plant should be met to have good growth.

**Repotting**

When the plants mature or overgrow in the pot they are to be repotted. The plant is carefully removed with earth ball intact. Congested roots and shoots are cutoff before repotting. The earth ball is reduced to the size and replanted in new pot with replenished soil and organic matter. Some of the plants do not require repotting, simply changing top soil of the pot serves the purpose. Some plants like fern, calathea, caladium, orchids and anthurium overgrow the pot in three years hence one should not change pot every year as they are very poor replanters at frequent intervals.

**Protection from Insects and Diseases**

**Insects:** Most of the plants are attacked by insects and pests. Mainly cell sap sucking insects are common in horticultural plants. Another important pest is leaf eating caterpillar. They feed on foliage of the plant and cause damage to the plants. It drastically

reduces the ornamental value of the plant. Sometimes the plant dies due to heavy infestation. This can be avoided by proper care of the plant, keeping good hygiene and cleanliness. If attack is severe spraying of insecticides such as Malathion 2 ml per litre water or Carbaryl 2 gm/litre can control the insects.

**Diseases:** Unlike pests, diseases also affect the health of the plant. Severe infection of the disease results into death of the plant. Most of the diseases are caused by fungi. The common diseases are wilt, blight, dieback and powdery mildew, all of them can be controlled by spraying of non systemic fungicides like mancozeb-2.5 gm, captan1-1.5gm, copper sulphate-2gm per lit of water. Copper oxy chloride-2.5gm and bavistin-1gm per lit are also permitted fungicide use to control diseases. The seed /plant treatment with fungicide at the time of planting also helps to reduce possibility of these infections. The disease causes discoloration of the foliage, occurrence of the spots, lesions, and death of the plant.

**Care of Preserved Plant Specimens**

**Protection from Insects:** The plant specimens prepared in the form of flashcards, herbarium, photocopies, photographs etc are likely to be attacked by termites, silver fish and cockroaches. They feed on cellulose of the paper and specimens. The best way to protect specimen is by plastic coating which prevents insect damage as well as loss due to excess moisture. Another way to protect specimen is to keep naphthalene tablets in the cupboards and store. This also helps to prevent attack of insects by repelling them.

Total insect control can be obtained by fumigation. A regular inspection of the samples enables proper care of the material.

Storage of specimen in glass or steel cupboards is secured and protected way to maintain the specimen in good condition.

**Non-Insect Pests:** Rodents are the major cause of damage the plant specimens. They chew the specimens into pieces and destroy them. Specimens should be stored in shelves and cabinets to keep them away from rodents. The control measures such as poisoning, fumigating and catching in cages reduces the risk of rodents.

**Wetting of Specimen:** The leakage in storage structures exposes the material to water and may destroy the collection. It is absolutely necessary to keep storage leak proof. Not only water but humidity and moisture can also prove fatal for the specimens to be stored. Hence the store should have auto closing glass door in addition to usual wooden doors. This minimizes the entry of moisture in the storage.

The plastic coated specimens are not affected by moisture. In heavy rainfall zone, heaters are installed to maintain proper temperature and reduce extra humidity or auto control ambient air conditioning is created.

Storage of specimen either in glass selves or steel cabinets also helps to avoid losses due to excess moisture or leaking.

**Protection from Fire:** Fire in building destroys the valuable collection. Generally it takes place due to short circuit, loose electric connections etc resulting into irreparable losses. Sometimes it happens due to human error. One must be very careful to avoid unforeseen losses of the plant library. Use of carbon cylinders as Anti-Fire device should be installed.

**Security from Theft:** Plant library is the best source of information and there is every possibility that the documented record may be stolen, hence it is necessary to maintain the security of the material by employing security guard.

## 9.2.5 Do's and Don'ts in Library Plants

- Select most popular plants and plants of commercial importance of the specific area.
- Prepare flash cards from pressed specimens.
- Use herbarium, photographs, photocopies for making plant library
- Develop plant cafeteria in institutional area
- Make elaborative list of plants and take care of material.
- Soft brush should be used to clean any unwanted sticking of dry specimens
- Store specimen in dust free and moisture proof container.
- Pressed specimen should be preserved in blotting sheets under some pressure
- Care should be taken to keep them free of insect attack.
- Different types of specimens sorted alphabetically should be pasted separately.
- The storage box or cabinet may be provided with glass viewer

A few plants popular in plant library,

**Climbers and Creeping Plants**

| Sr. No. | Common name | Botanical name | Season | Flower Colour | Propagation Method |
|---|---|---|---|---|---|
| 1 | Garlic climber Lasun Vel | *Adenocalymma alliaceum* | March to June | Pink mauve | Air layering and cuttings |
| 2 | Allamanda | *Allamanda cathartica* | Round the year | Yellow | Cutting air layers |
| 3 | Coral vine | *Antigonon leptopus* | Round the year | Pink | Seeds and cuttings |
| 4 | Arrebidaea | *Arrebidaea magnifica* | January and March | Purple crimson | Cuttings or layering |
| 5 | Nepal trumpet | *Beaumontia grandiflora* | Round the year | Purple | Cutting sucker |
| 6 | Waghnakhi | *Bignonia gracillis* | All year | White | Cutting layering |
| 7 | Bignonia | *Bignonia linguisati* | May, July | White | Cuttings and air layering |
| 8 | Bougainvillea | *Bougainvillea glabra* | July, September | Red Purple orange | Layering hard wood cutting |
| 9 | Velvet creeper | *Chonemorpha macrophylla* | October-November | Creamy white | Layer hard wood cutting |
| 10 | Clematis / Chameli | *Clematis panniculata* | September – October | White | Cutting / air layering |

| Sr. No. | Common name | Botanical name | Season | Flower Colour | Propagation Method |
|---|---|---|---|---|---|
| 11 | Clerodendron | *Clerodendron splendens* | Round the year | White | Suckers / layering |
| 12 | Creeping fig | *Ficus repens* | Round the year | Crimson coloured | Suckers |
| 13 | Madhavilata | *Hiptage madablata* | June September | Foliage walking | Hard wood cutting |
| 14 | Railway creeper | *Ipomea palmata* | All year round | White | Suckers / soft wood cutting |
| 15 | Jacquemontia | *Jacquemontia grandiflora* | July-September | Yellow | Seeds / cuttings |
| 16 | Jui | *Jasminum auriculatum* | July-September | White | Layering |
| 17 | Japanese Honeysuckle | *Loncera japonica* | July-September | White / Creamy | Cutting and layering |
| 18 | Jai | *Jasminum grandiflora* | July-September | White | Cutting seed layer |
| 19 | Passion fruit Krishnakamal | *Passiflora edulis* | September-November | White/ purple blue | Cutting seed layer |
| 20 | Krishnakamal Red ornamental | *Passiflora caerulea* | September-November | Red / purple | Seed, cutting layer |
| 21 | Purple wrath porana | *Petrea volubitis* | September-November | Blue / Purple | Layers suckers |
| 22 | Safedbel / porana | *Porana panniculata* | September-November | White | Cutting/suckers |
| 23 | Golden shower Sankrantwel | *Pyrostegia venusta* | January – February | Orange | Air layer cutting |
| 24 | Rupelia | *Rupelia grata* | July-September | White / Pinkish | Cutting |
| 25 | Rangoon creeper | *Quisqualis indica* | All year round | Red | Cutting air layering |
| 26 | Brinjal creeper | *Solanum jasmenoides* | All year round | Purple | Cutting layering |
| 27 | Tecoma | *Tecoma redicans* | July-September | Orange / Red | Cutting layering |
| 28 | Thunbergia | *Thunbergia alata* | July-September | Purple | Cuttings or layers |
| 29 | Monstera (Foliage) | *Monstera deliciosa* | - | Green foliage | Cutting |
| 30 | Money plant (Foliage), Pothos sp | *Scindapsus aureus* | | Green foliage | Soft wood cutting |

| Sr. No. | Common name | Botanical name | Season | Flower Colour | Propagation Method |
|---|---|---|---|---|---|
| 31 | Syngonium (Foliage) | *Syngonium podophyllum* | - | Green foliage | Suckers/ cuttings |
| 32 | Clerodendron | *Clerodendron thomsonae* | July-September | Scarlet white | Suckers/ cuttings |

**Flower of *Passiflora edulis***

***Bougainvillea glabra***

**Shrub Plants**

| Sr. No. | Common name | Botanical name | Flower Colour | Propagation Method |
|---|---|---|---|---|
| 1 | Chinese lantern Muki Jaswand | *Abutilon striatum* | Red orange | By seeds or cuttings |
| 2 | Green chafa | *Artabotrys odoratissimus* | Greenish yellow | Seeds and layer |
| 3 | Kanchan | *Bauhinia purpurea* | Purple pink creamy | Seed layer |
| 4 | Belaperone | *Beloperone guttata* | Yellow bronze | Cutting air layering |
| 5 | Bougainvillea | *Bougainvillea glabra* | Red orange yellow | HW cutting air layer |
| 6 | Shankusur, Peacock flower | *Caesalpinia pulcherrima* | Yellow orange | Seed |
| 7 | Powder puff | *Calliandra speciosa* | Red | Seed |
| 8 | Bottle brush | *Callistemon lanceolatus* | Red | Seed air layer |
| 9 | Yellow cassia | *Cassia biflora* | Yellow | Seed |
| 10 | Queen of night, Ratrani | *Cestrum nocturnum* | Creamy | Cuttings |
| 11 | Day jasmine | *Cestrum diurnum* | Yellow | Seed and cutting |
| 12 | Clerodendron | *Clerodendron inerme* | White scented | Cutting |
| 13 | Crossandra Aboli / Aboli | *Crossandra guineensis* | White orange | Seed |
| 14 | Duranta | *Duranta plumieri* | Purple blue | Cutting / softwood cutting |
| 15 | Variegated duranta | *Duranta variegata* | Purple blue | Tip cutting /softwood cutting |
| 16 | Golden duranta | *Duranta goldy* | Purple blue | Tip cutting /softwood cutting |
| 17 | Poincetia (Rakta-Parni) | *Euphorbia pulcherrima* | Red orange | Cutting |
| 18 | Galphimia | *Galphimia glauca* | Yellow | Cutting / seed |

| Sr. No. | Common name | Botanical name | Flower Colour | Propagation Method |
|---|---|---|---|---|
| 19 | Cape jasmine | *Gardenia jasminoides* | White | Cutting |
| 20 | Rat poison / Haamelta | *Hamelia patens* | Orange / Red | Cutting |
| 21 | Cup and saucer | *Holmskioldia sanguinea* | Orange red | Cutting / seed |
| 22 | China rose jaswand | *Hibiscus rosasinensis* | Red yellow | Cutting layering |
| 23 | Ixora | *Ixora coccinea* | Red, pink white | Cutting air layering |
| 24 | Jatropha coral plant | *Jatropha multifida* | Red orange | Cutting / seed |
| 25 | Pride of India Gulmehendi | *Langerstroemia indica* | Pink white | Air layer seed |
| 26 | Lantana ghaneri | *Lantana camara* | Yellow | Cutting |
| 27 | Mehendi | *Lawsonia inermis* | White | Cutting |
| 28 | Himachampa | *Magnolia grandiflora* | White | Layers grafting |
| 29 | Blue bell | *Meyenia erecta* | Blue | Cutting |
| 30 | Kamini | *Murraya exotica* | White sainted | Seeds air layering |
| 31 | Mussaendra | *Mussaendla corymbosa* | Yellow | Layering |
| 32 | Kanner / kanher tree of sadness | *Nerium oleander* | White pink | Cuttings or by layering |
| 33 | Parijatak | *Nyctanthes arbor tristis* | White | Seed |
| 34 | Pentas | *Pentas lanceolata* | Pink | Softwood cutting |
| 35 | Plumbago / chitrak | *Plumbago capensis* | Blue | Cutting |
| 36 | Weeping merry | *Russella juncea* | Violet | Suckers |
| 37 | Tecoma | *Tecoma stans* | Red | Cutting |
| 38 | Yellow oleander | *Thevetia nerifolia* | Yellow | Seed |

***Lantana camara***

***Ixora coccinea***

**Foliage Shrub Plants**

| Sr. No. | Common name | Botanical name | Flower Colour | Propagation Method | Uses |
|---|---|---|---|---|---|
| 1 | Thuja (Morpankhi) | *Thuja compacta* | Crimson red and brown | Seed /air layering | Foliage, ornamental |
| 2 | Acalypha (Green) | *Acalypha hispida* | Green | Semi-hard wood cutting | Foliage |
| 3 | Acalypha | *Acalypha wilkesiana* | Various colours | Semi-hard wood cutting | Foliage shrubs |
| 4 | Aralia | *Aralia* | Bronze red | Semi-hard wood | Border, hedge |

| Sr. No. | Common name | Botanical name | Flower Colour | Propagation Method | Uses |
|---|---|---|---|---|---|
| | | *veitchii* | | cutting | |
| 5 | Crotton | *Codiaeum variegatum* | Yellow green | Semi-hard wood cutting | Pot |
| 6 | Cuphea | *Cuphea ignea* | Variegated | Semi-hard wood cutting | Hedge |
| 7 | Golden | *Duranta goldy* | Red | Semi-hard wood cutting/ tip cutting | Potted / Hedge |
| 8 | Dracaena | *Dracaena drumemdii* | Yellow / green | Semi-hard wood cutting/ tip cutting | Cutting |
| 9 | Cordyline | *Dracaena cordyline* | Red | Semi-hard wood cutting/ tip cutting | Hedge |
| 10 | Green dracaena | *Dracaena excelsa* | Yellow green | Semi-hard wood cutting/ tip cutting | Potted / foliage |
| 11 | Eranthimum | *Eranthemum nervosum* | Green / yellow/ Red | Semi-hard wood cutting/ tip cutting | Potted / foliage |
| 12 | Pendanus (Kevda) | *Pendanum rosea* | Green / yellow | Suckers | Potted / foliage |
| 13 | Agave | *Agave filifera* | Green / yellow | Suckers | Potted / foliage |
| 14 | Green agave | *Agave Americana* | Green / yellow | Suckers | Potted / foliage |
| 15 | Chloropytum ribbon grass | *Chlorophytu m sp.* | Yellow / white stripped | Suckers | Hanging basket Edging |
| 16 | Nurgis eye / Rhohiyo | *Rhoeo spathacea* | Red / purple | Cutting/ suckers | Rockery / edging |
| 17 | Coleus | *Coleus blumei* | Red/orange | Softwood cutting | Potted / edging |

***Acalypha hispida***

**Croton (*Codiaeum varigatum*)**

**Bulb Plants**

| | **Common Name** | ***Botanical Name*** | **Propagation** |
|---|---|---|---|
| 1 | Lily | *Lilium longflorum* | Bulb |
| 2 | Amaryllis | *Amaryllis belladonna syn* | Bulb |
| | Amaryllis | *Hippeastrum equestre* | Bulb |
| 3 | Iris | *Iris japonica* | Bulbs |
| 4 | Lily miniature | *Crocus sp.* | Bulb |
| 5 | Gladiolus | *Gladiolus sp* | Corm |
| 6 | Dahlia | *.Dahlia pinnata* | Tuber,Seed |
| 7 | Canna | *Canna edulis* | Rhizome |
| 8 | Tuberose | *Polianthes tube rosa* | Tuber |

| | | | |
|---|---|---|---|
| 9 | Caladium | *Caladium bicolor* | Tuber |
| 10 | Tulip | *Tulipa pulchella* | Tuber |

**Bulb plant: *Lilium spp.***

***Amaryllis belladonna***

**Flowering Trees and Plants**

| Common Name | Botanical Name | Flower Colour | Season | Propagation Method |
|---|---|---|---|---|
| Amheritia | *Amherstia nobilis* | Purplish copper | February-May | Seed / air layering |
| Baobab/monkey bread tree | *Adansonia digitata* | Creamy white | June – September | Seed |
| Kanchan / Apta | *Bauhinia purpurea* | Purple pink | September - January | Seed / air layering |
| Flame of forest / | *Butea* | Orange | January- | Seed |

| Common Name | Botanical Name | Flower Colour | Season | Propagation Method |
|---|---|---|---|---|
| palas | *monssperma* | | March | |
| Bottle brush | *Callistemon lanceolatus* | Red / scarlate | June – January | Seed / air layering |
| Colvillea | *Colvillea racemosa* | Orange red | October-January | Seed |
| Kashid | *Cassia siamea* | Yellow | All year round | Seed |
| Pink cassia | *Cassia javanica* | Pink | June – October | Seed |
| Amalthas / Bahava | *cassia fistula* | Yellow | January-May | Seed |
| Pink cassia | *Cassia renigera* | Pink | June - October | Seed |
| Salmalia | *Bombax malabaricum* | Crimson red | January - February | Seed and cutting |
| Wild bhokar | *Cordia sebestina* | Orange or scarlate | July – October | Seed and sucker |
| Cannon ball | *Cauroupita guianensis* | Yellow cream | September - January | Seed |
| Gulmohar | *Delonix regia* | Orange / Red | February-May | Seed |
| Pangara | *Erythrina indica* | Orange / Red | February-May | Seed and cutting |
| Nil mohar / Jacaranda | *Jacaranda mimosaefolia* | Blue | July – October | Seed |
| Champaca / Sonchafa | *Michelia champaka* | Golden yellow | July – October | Seed / air layering |
| Indian cork tree / buch tree | *Millingtonia hortensis* | White | July – October | Seed / root sucker |
| Copper pod tree peltophorum | *Poltophorum feruginum* | Yellow | July – October | Seed |
| Temple tree / white chafa | *Plumeria alba* | White | July - October | Seed and cutting |
| Temple tree / pink chafa | *Plumeria rubra* | Pink | July - October | Seed and cutting |
| Fountain tree / Indian Tulip tree | *Spathodea campanulata* | Scarlate orange | July - October | Seed |
| Hadga | *Sesbania grandiflora* | Cream white | July - October | Seed and cutting |
| Tabebuia | *Tabebuia* | Yellow | January – | Seed |

| Common Name | Botanical Name | Flower Colour | Season | Propagation Method |
|---|---|---|---|---|
| | *spectabitlis* | | March | |
| Ranpimpal/ Bhendi | *Thespesia popullnea* | Yellow | All year round | Seed and cutting |

***Delonix regia***

***Erythrina indica* in bloom**

***Plumeria alba***

**Shade Plants:**

| Common name | Botanical name | Propagation Method | Uses |
|---|---|---|---|
| Babhul | *Acacia arabica* | Seed | Shade road avenue |
| Shrish | *Albizzia lebbek* | Seed | Shade road avenue |
| Neem | *Azadirachta indica* | Seed | Shade road avenue |
| Wad / banyan | *Ficus bengalensis* | Seed and cuttings | Shade road avenue |
| Pimpal | *Ficus religiosa* | Seed or cuttings | Shade road avenue |
| Umbar | *Ficus glomerata* | Seed or cutting | Shade road avenue |
| Rubber plants | *Ficus elastica* | Seed/cutting/layering | Shade road avenue |
| Wad / chilkhan | *Ficus retusa* | Seed/cutting/layering | Shade road avenue |
| Cadamba | *Anthocephalus cadamba* | Seed/cutting/layering | Shade road avenue |
| Filicium | *Filicium decipiens* | Seed or cutting | Ornamental foliage |
| Silver oak | *Grevillea robusta* | Seed | Ornamental foliage |
| Juniper | *Juniperous roxburghii* | Seed and layering | Ornamental foliage |
| Monkey bread | *Kigelia pinnata* | Seed | Shade road avenue |
| Sisso | *Dalbergia sisoo* | Seed | Shade road avenue |
| Raintree | *Samania saman* | Seed | Shade road avenue |

| Common name | Botanical name | Propagation Method | Uses |
|---|---|---|---|
| Karanj | *Pongamia glaboa* | Seed | Ornamental foliage |
| Shatputri | *Putranjiva roxburghii* | Seed | Ornamental foliage |
| Wild almond | *Terminalia catappa* | Seed | Shade road avenue |
| Thuja compacta | *Thuja occidentalis* | Seed or cutting | Ornamental foliage |

**Avenue plantation of Silver Oak (*Grievellia robusta)***

## Tall Ornamental Hedge Plants

| Sr | Common Name | Botanical Name | Propagation Method | Colour of Flower |
|---|---|---|---|---|
| 1 | Kanchan | *Bauhinia purpurea* | Seed | Blue, purple, orange |
| 2 | Bougainvillea | *Bougainvillea glabra* | Layering | Red, pink, orange, white |
| 3 | Shunkasur / Peacock | *Caesalpinia pulcherrima* | Seed | Orange, red |
| 4 | Powder puff | *Calliandra speciosa* | Seed | Red, orange, yellow |
| 5 | Night queen | *Cestrum nocturnum* | Layering | Creamy white |

| | | | | |
|---|---|---|---|---|
| 6 | Clerodendron | *Clerodendron inerme* | Hard wood cutting | White |
| 7 | Duranta | *Duranta pulmeri* | Hard wood cutting, Tip cutting | Blue, orange |
| 8 | Ponicetia Raktparni | *Euphorbia pulcherrima* | Cuttings | Red orange |
| 9 | Galphimia | *Galphimia glauca* | Hard wood cutting, Sucker | Yellow |
| 10 | Hamelia Rat's poison | *Hamelia patens* | Hard wood cutting | Orange, red |
| 11 | Cup and saucer | *Holmskioldia sanguinea* | Hard wood cutting | Orange yellow, red |
| 12 | Hibiscus Jaswand | *Hibiscus rosasinensis* | Hard wood cutting, Layering | Orange yellow, red |
| 13 | Ixora / Rukhmini | *Ixora coccinea* | Hard wood cutting, Layering | Rose, pink, red |
| 14 | Cassia yellow | *Cassia biflora* | Seed | Yellow |
| 15 | Gul-Mehendi | *Lagerstromia indica* | Hard wood cutting, Layering | White |
| 16 | Mehendi | *Lawsonia inermis* | Hard wood cutting, Layering | White pink |
| 17 | Blue bell | *Mayenia erecta* | Hard wood cutting, Sucker | Blue |
| 18 | Kamini | *Murraya exotica* | Hard wood cutting, Seeds, Layering | White |
| 19 | Nerium Kanher | *Nerium oleander* | Cutting | Rose, pink, red, white |
| 20 | Tecoma | *Tecoma stans* | Cutting | Yellow |
| 21 | Yellow oleander | *Thevetia nerifolia* | Cutting | Yellow |

***Bauhinia purpurea***

**Tall Hedge Plant *Duranta plumeri***

***Nerium oleander***

**Dwarf Ornamental Plants:**

| Sr. No | Common name | Botanical name | Propagation Method | Colour of Flower |
|---|---|---|---|---|
| 1 | Lantana | *Lantana camera* | Cutting, seed | Yellow, saffron, red |
| 2 | Crossandra | *Crossandra guineensis* | Cutting, seed | Bricked orange |
| 3 | Bela perone | *Bela perone* | Cutting | Yellow bronze |
| 4 | Plumbago | *Plumbago capensis* | Cutting, sucker | Blue |
| 5 | Weeping merry | *Russelia juncea* | Cutting, sucker | Red |
| 6 | Golden duranta | *Duranta gold* | Hard wood cutting | Blue |

**Foliage Hedge Plants**

| Sr. No. | Common name | Botanical name | Propagation Method | Colour of Flower |
|---|---|---|---|---|
| 1 | Agave | *Agave Americana* | Bulbils | Foliage |
| 2 | Kewada | *Pandanus rosea* | Sucker | Foliage |
| 3 | Acalypha | *Acalypha wilkesiana* | Soft wood cutting | Foliage |
| 4 | Aralia | *Aralia xeitehi* | Soft wood cutting | Foliage |
| 5 | Croton | *Codiaeum varigata* | Soft wood cutting | Foliage |
| 6 | Coleus | *Coleus blumei* | Tip cutting | Foliage |
| 7 | Dracaena | *Dracaena excelsa* | Tip cutting | Foliage |

***Dracena sp.***

***Acalypha wilkesiana***

**Protective Tall Hedge Plants**

| Sr | Common name | Botanical name | Propagation Method | Colour of Flower |
|---|---|---|---|---|
| 1 | Willayati chinch | *Inga dulcis* | Seed | Protective thorny |
| 2 | Karonda | *Carissa carandas* | Seed layering | Berry and foliage |
| 3 | Ornamental babhul | *Acacia farnesiana* | Seed | Yellow flower, thorny |
| 4 | Drooping ashoka | *Polyalthia longifolia* | Seed | Foliage |
| 5 | Nilgiri | *Eucalyptus citriodora* | Seed | Foliage |
| 6 | Fish tall palm | *Raphis excelsa* | Seed | Foliage |

***Carissa congesta***

**Edging Plants**

| Sr | Common name | Botanical name | Propagation Method | Colour of Flower |
|---|---|---|---|---|
| 1 | Ageratum | *Ageratum sp.* | Cutting | Edging |
| 2 | Alternanthera | *Alternanthera* | Cutting | Edging ground cover |
| 3 | Coleus | *Coleus blumei* | Soft wood cutting | Edging folias |
| 4 | Justicia | *Justicia carnea* | Cuttings | Edging dwarf hedge |
| 5 | Pilea | *Pilea muscosa* | Soft wood cutting | Foliage hanging basket |
| 6 | Portulaca | *Portulaca grandiflora* | Soft wood cutting | Foliage hanging basket |
| 7 | Iresin | *Iresin Sp.* | Soft wood | Foliage hanging |

| | | | | |
|---|---|---|---|---|
| | | | cutting | basket |
| 8 | Plumbag | *Chlorophytum comosum* | Seed, Hard wood cutting | Foliage hanging basket |
| 9 | Rhoeo | *Rhoeo spathacea* | Sucker, Stem cutting | Foliage edging |
| 10 | Grass Hariali | *Cynodon dactylon* | Sucker, Cutting | Edging lawn |
| 11 | Golden duranta | *Duranta goldy* | Tip cutting | Edging lawn |
| 12 | Miniature | *Rosa hybrida* | Budding | Edging hanging basket |
| 13 | Blue | *Plumbago sp.* | Cutting | Edging |

***Alternanthera sp.***

**Seasonal /Annual Flowering Plants:**

| Sr. No | Common Name | Botanical Name | Family | Flower Color | Season | Remarks |
|---|---|---|---|---|---|---|
| 1 | Aster | *Callistephus chinensis* | Compositae | Blue, pink, white | Winter | Bedding, pot culture and a good cut flower |
| 2 | Calendula | *Calendula officinalis* | Compositae | Orange | Winter | Bedding, pot culture and a good cut flower |
| 3 | Hollyhock | *Althaea rosea* | Malvaceae | White, pink, red, crimson, yellow | Winter | Screening purpose as a background border |
| 4 | Annual chrysanthem | *Chrysanthemum* | Compositae | White and | Winter | Bedding purpose |

| Sr. No | Common Name | Botanical Name | Family | Flower Color | Season | Remarks |
|---|---|---|---|---|---|---|
| | um | *coronarium* | | yellow | | |
| 5 | Cosmos | *Cosmos bipinnatus* | Compositae | White, pink, yellow | All year round | Bedding purpose |
| 6 | Cock's comb | *Celosia argentea* | Amaranthacea | Yellow, orange, red | All year round | Beds and border |
| 7 | Dahlia | *Dahlia variabilis* | Compositae | White, pink, yellow, orange | All year round | Suitable pots, beds, rockery and cut flower |
| 8 | Carnation | *Dianthus caryophyllus* | Caryophyallaceae | White, pink, yellow, orange, purple | All year round | Cut flowers, beds and borders |
| 9 | Petunia | *Petunia hybrida* | Solanaceae | White, pink, yellow, blue | Winter | Pots, beds and hanging baskets |
| 10 | Phlox | *Phlox drummondii* | Polemoniaceae | White, pink, yellow, blue, cream | Winter | Beds, borders and window boxes |
| 11 | African marigold | *Tagetes erecta* | Compositae | Yellow, orange, blue, white | All year round | Cut flowers, beds and borders |
| 12 | French marigold | *Tagetes patula* | Compositae | Yellow, orange, red | All year round | Bedding and pot culture |
| 13 | Mexican sunflower | *Tithonia rotundifolia* | Compositae | Orange | All year round | Bedding, pot culture and a good cut flower |
| 14 | Gaillardia | *Gaillardia pulchella* | Compositae | Yellow, orange | All year round | Bedding, pot culture and a good cut flower |
| 15 | Bachelor's buttons | *Gomphrena globosa* | Amaranthaceae | White, pink, purple | Summer and rainy | Screening purpose as a background border |

| Sr. No | Common Name | Botanical Name | Family | Flower Color | Season | Remarks |
|---|---|---|---|---|---|---|
| 16 | Zinnia | *Zinnia elegance* | Compositae | White, pink, yellow, orange and red | Summer and rainy | Bedding purpose |
| 17 | Sadaphuli / periwinkle | *Vinca rosea* | Apocynaceae | Purple, white | All year round | Bedding purpose |
| 18 | Salvia red | *Salvia splendens* | Labiatae | Red | All year round | Beds and border |
| 19 | Flox flower | *Ageratum mexicanum* | Compositae | Pale lavender | All year round | For edging and flower bed |
| 20 | Sweet William | *Alyssum maritimum* | Cruciferae | White, rose, pink, lilac | *Khairf* | Flower beds |
| 21 | Antirrhinum / Snap dragon | *Antirrhinum majus* | Scrophulariaceae | Various colours | Winter | Flower beds |
| 22 | Amaranth | *Amaranthus caudatus* | Amaranthaceae | White, pale green, crimson | *Kharif* | Flower bed |
| 23 | Tick – seed / calliopsis | *Coreopsis drummondii* | Compositae | Yellow, crimson, brown | All year round | Flower beds |
| 24 | Foxglove | *Digitalis purpurea* | Compositae | White, apricot, crimson | *Kharif* (July-Aug) | Flower beds |
| 25 | Treasure flower / Gazania | *Gazania splendens* | Compositae | Pink, orange, yellow, red | Winter / summer | Flower bed |
| 26 | Sunflower | *Helianthus annuus* | Compositae | Yellow | *Kharif* | Flower bed |
| 27 | Strawflower / Helichrysum | *Helichrysum bracteatum* | Compositae | Silvery white to rich yellow | *Kharif* (Aug – Sep) | Flower bed / dry flower |
| 28 | Balsam | *Impatiens balsamina* | Balsaminaceae | Rose, pink, violet | *Kharif* | Flower bed |
| 29 | Statice | *Minonium sinuatum* | Plumbaginaceae | Rose, mauve, lavender | *Kharif* / winter | Flower bed / dry flower |

| Sr. No | Common Name | Botanical Name | Family | Flower Color | Season | Remarks |
|---|---|---|---|---|---|---|
| 30 | Viola | *Viola cornuta* | Violaceae | Various colours | Winter | Flower beds and edging |

***Tagetes erecta***

***Gromphrena globosa***

## 9.3 Glossary

**Annuals:** Plants which complete their lifecycle within one season or year

**Biennials:** Plants which complete their lifecycle in two seasons or years

**Bulbs:** They are underground parts which have bud surrounded with food material.

**Digitization:** Computerized database of plants which can be converted into visual form and can have multiple accesses.

**Flashcards:** These are index cards with pressed specimens or pictures with names

**Herbarium:** It is a collection of dried plant specimen.

**Indoors:** Plants which grow under cover, either in full or partial shade.

**Perennials:** Plants which grow for more than two years.

**Soil media:** It is soil used to plant any seedling or tree.

## 9.4 Points To Remember

1. Plant library is the collection of the plants in live and preserved form to provide information on plants.
2. Methods of plant collection for plant library include, live plants, flash cards, photographs, photocopies, bibliography, digitization, etc.
3. Plant library should have collection of commercially important species, utility and academic interest.
4. Relevant information of plant should be available in library and on sheets of specimens.
5. Instructional farms of institutes must have plant cafeteria for academic purpose.
6. Open areas should be used for tree planting and beautification of the premises.
7. Corporate offices exhibit exclusive collection of beautiful plants to create best landscape and garden.
8. Commercially important plants for gardening, medicine, industry and culinary should be part of library collection
9. Soil and climate is an important factor in introducing plants from other localities
10. Protect preserved specimen form natural calamities like rain, fire, insects, dust and other factors such as chemicals, theft etc.

## 9.5 Self Check Questions

1. Define following terms in relation to the plant collection,
   Plant library, Herbarium, Annuals, Biennials, Perennials, Indoors
2. What are the important aspects taken into account while selecting plants for institutions, public places, and corporate offices?
3. What care should be taken while applying water to the plants?
4. Why should we feed the plants and what are important considerations while feeding?
5. What are the operations involved in maintenance of live plants?

## 9.6 Do It Yourself

1. Select and collect best garden plants growing in your area and plant them in your institute.
2. Grow indoor plants in your institute and at home in pots.
3. Prepare growing media of soil + compost and fill the pots by placing brick gravel and coarse sand at drain hole.
4. Photograph the best ornamental and valued plants for library and prepare album for plant library.
5. Visit best gardens, corporate offices and public area with tree plantation and make a short note on visit.
6. Identify the diseases and pests of the plants and undertake control measures for them.

# Unit 10: Economics and Government Regulations in Horticulture Nursery

***Index***



## 10.1 Introduction

Nursery is a place where horticultural plants like fruit plants, ornamental plants, flowering plants and seedlings are raised, multiplied, propagated and supplied to growers. Nursery management has gained a status of commercial venture where retail nurseries sell planting materials to the growers and general public. There are also wholesale nurseries which sell only to other nurseries and to commercial landscape gardeners, while private nurseries which supply the needs of institutions or private estates. Since most of the horticultural crops are propagated by the nurseries, the document covers all the related aspects to nursery for production of quality planting materials.

**At the end of this unit, you will be able to know and understand:**

- Capital investment in nursery development.
- Process of distributed nursery production.
- Know the government loan and subsidy for nursery development.
- Analyze income, expenditure, and profit in nursery management.
- Understand the role of horticultural nurseries in entrepreneurship development.

## 10.2 Contents

### 10.2.1 Capital Investments in Nursery Development

The size and intensity of the nursery operation determine the capital requirement. A large volume nursery requires a full-time manager and considerable capital investment. A small volume nursery can be a part-time job and requires less capital investment. Another

approach is to expand an existing farm operation. A farmer seeking an alternative crop has much of the necessary equipment and requires less fixed capital investment.
A plant nursery requires various capital components of expenditure like land, building, road, fencing, polyhouse, shade net, equipment and machinery, well/tubewell, motor, irrigation system etc. The cost and expenditure components for non-recurring heads are included under capital components. For ease of understanding and practical aspects of establishment of plant nursery an area of 1 hectare is considered. This module will help the reader to arrive at a firm decision to start his own nursery.

**Basic Considerations**

- Whether the entrepreneur has skill and knowledge to grow plants
- Whether the entrepreneur has strong will power and right mind set to establish a nursery
- Whether the entrepreneur has access to adequate means of finance
- Whether the entrepreneur has adequate raw material for establishment of nursery
- Whether there is demand of nursery plants for sale to the farmers or retrading.
- Whether he has land for nursery easily approachable for all the buyers.

The answers to above questions strongly put up by a probable entrepreneur will help him to arrive at a firm decision to start a nursery enterprise. Capital components are those components of investments which are required to be incurred for capital intensive and non-recurring items for establishment of nursery enterprise. The cost for such component is borne during the establishment phase and further expenditure may be incurred for maintenance of capital structures.

**Capital Components**

Nursery is the place where all kinds of plants like trees, shrubs, climbers etc. are grown and kept for transporting or for using them as stock plants for budding, grafting and other method of propagation or for sale.

The establishment of a nursery may require following fixed capital components:

1. **Fence:** Prior to the establishment of a nursery, a good fence with barbed wire must be erected all around the nursery to prevent trespassing of animals and theft. The fence could be further strengthened by planting a live hedge with thorny plants (like Karvanda).
2. **Roads and Paths:** A proper planning for roads and paths inside the nursery will not only add aesthetic value, but also make the nursery operations easy and economical. This could be achieved by dividing the nursery into different blocks and various sections. But at the same time, the land should not be wasted by unnecessarily laying out of paths and roads. Each road/ path should lead the customer to a point of interest in the nursery area.
3. **Workshed:** Workshed of 5 m x 4 m with thatched roof of locally available materials like bamboo, wood, etc. may be constructed.


**Mother Plant Block for Mango Nursery**

4. **Mother Plant Block:** The nursery should have a well-maintained progeny block or mother plant block or scion bank with plants of varieties in demand. The grafts, layers, rooted cuttings and seedlings should be obtained preferably from the original breeder or research institute from where it is released or from a reputed nursery. The success of any nursery largely depends upon the initial selection of progeny plants or mother plants for further multiplication. In this chapter, the mother plants of Mango, Pomegranate, Guava, Aonla, Custard apple and 25 other ornamentals are considered for plantation on 0.50 hectare area
5. **Irrigation System:** Horticultural nursery plants require abundant supply of water for irrigation, since they are grown in polybags or pots with limited quantity of potting mixture. Hence it is necessary to have sufficient number of wells to yield sufficient quantity of irrigation water. In areas with low water yields and frequent power failures, a sump to hold sufficient quantity of water to irrigate the nursery plants is also essential along with appropriate pump for lifting the irrigation water. In areas where electricity failure is a problem which is common, an alternate power supply (generator) is necessary for smooth running of pump set. Since water is a limiting factor, a well laid out PVC pipeline system will solve the problem to a greater extent. This facilitates efficient and economic distribution of irrigation water to various components in the nursery.
6. **Office cum Stores:** The office building may be constructed at a place which offers better supervision and is also presentable enough to receive customers. The office building may be suitably decorated with attractive photographs of fruits and ornamental plant varieties propagated in the nursery with their details. A store room of suitable size is needed for storing polybags, tools and implements, packaging

material, labels, pesticides, fertilizers etc. A store-cum-office of 6.0 m x 4.5 m constructed with locally available materials may serve the purpose.

7. **Seed Beds:** In a nursery, this component is essential to raise the seedlings and rootstocks. These are to be laid out near the water source, since they require frequent watering and irrigation. One meter wide beds of convenient length are made. A working area of 60cm between the beds is necessary. This facilitates ease in sowing of seeds, weeding, watering, spraying and lifting of seedlings. Irrigation channels are to be laid out conveniently. Alternatively, sprinkler irrigation system may be provided for watering the beds, which offers uniform germination and seedling growth.
8. **Nursery Beds:** Raising of seedlings and rootstocks in polybags requires more space compared to nursery beds but mortality is greatly reduced along with uniformity in plant growth. Nursery bed area should also have a provision to keep the grafted plants either in trenches 30cm deep and 1 m wide so as to accommodate 500 grafts /layers in each bed. The grafts/ layers can be arranged on ground in form of 1 m wide beds. There must be a 60cm working place in between the beds to facilitate irrigation either with a spray attachment fitted to a flexible hosepipe or by overhead micro-sprinklers.
9. **Potting Mixture and Potting Yard:** For better success of nursery plants, a good potting mixture is necessary. The potting mixtures for different purposes can be prepared by mixing fertile red soil or riverbed soil of tested pH ranging between 6.5 to 7 and electrical conductivity less than 0.5 mmhos/cm. The soil can be mixed in well decomposed FYM, leaf mold, oil cakes etc. as organic supplement and sand in 2:1:1 proportion. The potting mixture must be prepared well in advance by adding sufficient quantity of superphosphate for better decomposition and solubilization. The potting mixture may be kept near the potting yard, where potting or bag filling is done. Construction of a potting yard of suitable size facilitates potting, bag filling of seedlings, grafting and budding operations even on a rainy day.

**Structures for Nursery**

**Shade Houses:** Shade net houses in nurseries in tropical and sub-tropical regions offer many advantages like raising of seedlings in bags directly, protecting the grafts from hot summer months, effective irrigation through upside down overhead microsprinklers. Shade nets (50% or 75%) are used in shade houses for regulation of shade. They are particularly useful in arid regions where the humidity is very low during summer months. A nursery requires around 400 square meter area of shade house to produce 40000 to 50000 plants in a year.

**Green Houses/Polyhouses:** The success rate of grafting or budding of several fruit species under polyhouses or low cost green houses with natural ventilation is more, besides; the growth of grafts is also faster due to favorable micro climatic conditions in the polyhouse. In all polyhouses or green houses means of providing air movement and air exchange is necessary to aid in controlling temperature and humidity. A green house with heating system, self opening ventilators, and evaporative cooling systems are more preferable. A nursery must have a poly house over 200 $m^2$ area.

**Mist Chamber:** This is a structure used to propagate soft wood cuttings, difficult to root plants and shrubs. Here the cuttings are sprayed with minimum quantity of water through a series of intermittent sprayings rather than a continuous spray. The intermittent spraying can be done easily by means of a high pressure pump, pipeline system and a time switch. The mist nozzles are fitted to these pipelines and suitably spaced over the propagating material in the chamber. A mist chamber of 15 square meters area is sufficient for a nursery.


**Mist Chamber**

**Polytunnels:** It is a small tunnel-like structure. It is 2 meter wide and 10 meter long with a height of 1.2 meter. It is a steel frame covered with 200 micron polythene sheets. The structure is used for germinating seedlings and to achieve optimum growth before being transplantation. A 150 meter square polytunnel would suffice the needs of a nursery.

An expenditure on different capital components is incurred for establishment of nursery which is mentioned as follows

## 10.1.4 Capital Cost of Development of Nursery (1.0 Hectare)

| Sr No | Particulars | Quantity | Rate in Rs | Year I | Year II | Year III | Total |
|---|---|---|---|---|---|---|---|
| 01 | Fencing | 400 sq.m. | 40 | 16000 | 0 | 0 | 16000 |
| 02 | Workshed | 20 sq.m. | 500 | 10000 | 0 | 0 | |
| 03 | Mother Plant Block | 6000 sq.m. | 5 | 30000 | 5000 | 4000 | 39000 |
| 04 | Irrigation with pipeline | 10000 sq.m. | 13.5 | 135000 | 4000 | 4000 | 143000 |

| Sr No | Particulars | Quantity | Rate in Rs | Year I | Year II | Year III | Total |
|---|---|---|---|---|---|---|---|
| 05 | Office cum Store | 27 sq.m. | 500 | 13500 | 0 | 0 | 13500 |
| 06 | Shadenet House | 400 sq.m. | 275 | 110000 | 0 | 0 | 110000 |
| 07 | Polyhouse | 200 sq.m. | 500 | 100000 | 0 | 0 | 100000 |
| 08 | Mist Chamber | 15 sq.m. | 250 | 3750 | 0 | 0 | 3750 |
| 09 | Polytunnel | 150 sq.m. | 250 | 37500 | 0 | 0 | 37500 |
| 10 | Land preparation, nursery beds, internal roads, pathways, potting yard | 2000 sq.m. | 10 | 20000 | 0 | 0 | 20000 |
| 11 | Water Storage | 1 unit | - | 25000 | | | 25000 |
| | Total | | | 500750 | 9000 | 8000 | 517750 |

(Based on average prices during 2008-10)

## 10.2.2 Distributed Nursery Plant Production and Marketing

**Types of Nursery Enterprises**

The nursery enterprise comprises production of different types of plants for sale like, fruit plants, ornamental plants, vegetable seedlings, forest trees etc. Better quality of seedlings and grafts improves the salability of plants from the nursery. The various types of nurseries provide employment for skilled and unskilled labor. It also makes plants available for plantations, landscaping, and beautification.

Different types of nursery plant production can provide avenues of employment and availability of plants through sale. It includes the following types nursery based enterprise:

- Fruit Plants Nursery
- Ornamental Plant Nursery
- Forest Plant Nursery
- Vegetable Seedling Nursery
- Medicinal and Aromatic Plants Nursery
- Retail Nursery
- Wholesale Nursery
- Plant Library Nursery
- Landscape Gardening Consultancy
- Tissue Culture Nursery
- Secondary Hardening Nursery
- Flowering Plant Nursery

- **Fruit Plants Nursery**

  The fruit plants nursery produces fruit plants and grafts of improved varieties for plantations. The varieties vary with different agro-climatic zones and regions. It is

important that the nurseries produce fruit plants and grafts as per demand of the crop in a particular region. For example, farmers demand cashew grafts in Konkan area. However, the demand for cashew grafts would be limited in other areas which do not grow cashew traditionally.

- **Ornamental Plant Nursery**

  The ornamental nursery provides various indoor and outdoor, flowering and non-flowering, plants of aesthetic value. These nurseries generally provide to the needs of the urban dwellers, Institutes, and various establishments. These nurseries produce various plants like, indoor and outdoor plants, flowering trees seedlings, shrubs, creepers. They supply their products for bungalows, establishments, and institutes in urban centers. The ornamental plant nursery also supplies planting material for terrain landscaping including lawns and grasses, hedge plants, etc. Most of these plants are provided polybags only if the plant is large it is supplied in a pot. The cost of potted plants is more than those sold in polybags as the plants in pot are large in size, more in age, and the cost of the container is also higher than polybags.

- **Forest Tree Nursery**

  Various flowering forest trees are produced in nursery. The forest nurseries have a mandate of production of various forest trees for afforestation program in reserve areas. Most of these plants are not available for sale to lay man. However some flowering tree plants are in demand in urban areas and townships. These flowering trees are used for plantation in these areas for avenue plantation on the sides of roads and pathways.

- **Vegetable Nursery**

  There is huge demand of vegetable seedlings during kharif, rabbi and summer seasons. Most of the farmers prefer planting readymade seedlings prepared in commercial nurseries. The nurseries prepare hybrid seedlings of the various crops like tomato, chilies, marigold, capsicum, brinjal, etc. The use of these seedlings for transplanting saves time and labour for the vegetable growers. The vegetables seedlings are made available to farmers during the growing season. The seedlings are grown in propagation trays. The vegetable seedlings are 18 to 40 days old when they are supplied to the farmers. Coco peat is often used for growing vegetable seedlings as it is one of the most congenial media for propagation of seedlings. It is also the fastest and easiest method of raising the seedlings. The cost of production of vegetable seedlings in propagation trays varies from Rs 0.60 to Rs 2.00 per plant depending upon the variety and type of crop. The seedlings are raised in shade net house or polyhouse or polytunnels. Annually, one acre vegetable nursery can produce 1 to 4 lakhs seedlings depending upon the demand and marketing strategy.

- **Medicinal and Aromatic Plants Nursery**

  There is increasing awareness of farmers and urban dwellers on use and advantages of various medicinal and aromatic plants. These plants are demanded by growers who produce medicinal or aromatic plants for different pharmaceutical industries. *Aloe vera,* sarpagandha, ashwagandha, *Asparagus racemosus*, adulsa, *Vinca rosea*, senna, *Bacopa monnieri*, aonla, hirda, behda, safed musali, mint, basil, citronella,

lemongrass, khus etc are important crops which are processed for their medicinal and aromatic value. Many plants like mint, citronella, lemongrass, safed musali are grown as commercial plantation by the farmers. Such plants are traded for their high value oils and tuber powder.

Most of these medicinal and aromatic plants are supplied through nurseries of State Agricultural Universities and nurseries established under the support of National Medicinal Plants Board or under National Horticulture Mission.

- **Wholesale and Retail Nurseries**

  The wholesale nurseries prepare the seedlings and grafts of various ornamentals and fruit plants on a large scale and supply them to different small retail nurseries. Retail nurseries procure these plants from the wholesalers in bulk quantities. They supply these plants to individual customers after adding transportation, maintenance and profit margins to the cost.

- **Plant Tissue Culture and Secondary Hardening Nurseries**

  Various Plant Tissue Culture Laboratories produce tissue cultured plants of Banana Gerbera, orchids, etc for commercial cultivation. The tissue culture plants are produced aseptically under environmentally controlled conditions in glass jars and bottles. The production of such tissue culture plants is called micropropagation. Most of the tissue culture plants are highly sensitive to environmental stress and different diseases and pests.

  Such plants should therefore be hardened in shade net house conditions before they are planted in the field. The rearing of such tissue culture plants at secondary stage is called Hardening and the nurseries undertaking such hardening of tissue culture at secondary stage before plantation are called Secondary Hardening Nurseries. The secondary hardening nurseries are an important source of supply of tissue culture hardened plants in different parts of the country. Additionally, it has become an important source of employment for entrepreneurs.

- **Plant Library Nurseries**

  The establishment of plant libraries is relatively a new concept. It is the supply of different ornamental plants which is similar to the issue of books for the readers from a library. The plant library supplies plants in to various landscapers and event managers for cultural and social events, gatherings and functions. The customer pays a fixed sum for the plants in order to beautifying the venue of the function. The plants are returned back to the library after their purpose is served.

  Different office establishments require ornamental plants, potted plants and bouquets of flowers for beautification. This service is provided on rental basis. Such a system of supply of ornamental plants to various office establishments generates employment opportunities for entrepreneurs and nurserymen.

- **Landscape Gardeners**

  Landscape gardener is a master gardener who supplies and undertakes plantation of flowering trees, ornamental plants, shrubs, bushes etc for beautification of surroundings, terrain or landscape based on shape, slope, location, type of soil etc. The landscape gardeners provide basic groundwork for plantation of various

ornamental trees and plants around the buildings, office establishments, premises etc. The landscape gardeners provide these plantation services on payment of fixed fees. Some gardeners also provide complete gardening establishment experts on turn-key basis after careful survey and assessment of site and terrain.

- **Flowering Plant Nursery**
  The flowering plant Nurseries are those nurseries which produce various types of flowering ornamental plants.

**Marketing of Plants from Nurseries**

The nursery is an occupation providing employment to skilled and unskilled personnels. The success of horticulture nursery depends on appropriate marketing skills. The production of various plants in the nursery is done during rainy season and is reared for the subsequent period before it is made available for sale during the next plantation season.

- **Preparation of Nursery Plants before Sale**
  All the plants propagated in nursery are made available for sale during the upcoming season when there is adequate demand for plants. A successful nurseryman makes various plants of improved variety available for the farmers. The plants in demand are prepared for sale during the ensuing season. These plants should be made available well in time. It is therefore important for the nursery entrepreneurs to make a thorough survey and study of demand and gap in supply of different nursery plants. The nursery entrepreneur should book the demand from various customers well in advance to market plants successfully during the next season.
  The demand survey regarding requirement of different plants is to be done in order to ascertain the place and time of demand and to get an idea of the existing rates of plants in other nurseries. Any lack of information on demand survey of nursery plants in the area of can lead to difficulty in sale and may also cause poor recovery of payment for supplied plants. The cost of various nursery plants can be fixed depending on the age of plants, height of plants, variety, propagation technique used, production cost, maintenance costs etc.
- **Time of Sale of Nursery Plants**
  It is an important point to be considered before the plants are propagated and made available for sale. The sale of plants is required to be undertaken when there is adequate demand. Usually the nursery plants are in great demand during the rainy season. Monsoon is a favorable season for plantation of various nursery plants as humidity helps transplanted plants to establish in the field. The favorable months for sale of plants start from June and continue till the end of September. There is less demand for plants from October to January while there is almost no demand for plantation during hot summer months from February to May. Therefore maximum sale of plants should be planned from June to September only. The vegetable nursery plants are the only exception to this and are in great demand throughout the year. Vegetable seedlings can therefore be made available for sale at any time of the year depending upon the demand.

The fruit grafts and seedlings are to be sold after attaining an age of six months. Fruit grafts can easily be established in field only after six months of age. If the plants are sold before the recommended age and height, plants may show higher mortality rate in the field. The vegetables seedlings are an exception to this and have to be sold from 25 to 40 days period. Seedlings above 40 days of age must not be sold with an exception to some hybrid varieties of tomato, etc which are ready for sale in 20 to 25 days.

**Publicity and Advertisement for Sale of Nursery Plants**

There should be adequate publicity and advertisement of availability of various grafts, seedlings in the nursery. Such publicity and advertisement helps in sale and supply of plants at appropriate rates and time.

Different strategies of publicity and advertisement can be adopted for sale of plants from the nursery which may include the following:

1. Sales area: The area where the plants are to be sold need to be ascertained well in time. A thorough survey of the area available must be done before finalizing the sales area. The sales area must not be a very far off and remote place.
2. Advance booking: This type of system is advantageous to both nurserymen as well as the customers. Advance information on probable requirements of plants for sale helps the farmer to finish the plantation well in time and as per the requirement.
3. Information through Gramsabhas: The information on availability of plants can be provided through various training programmes organized by the Agricultural Department and also during the village level meetings. Occasion such as Gramsabhas, etc. can be utilized by the nurserymen to make adequate publicity on type of plants, variety, method of plantation and other technical aspects of care and control of insect and pests etc.
4. Exhibiting through Stall: The plants can be made available for sale by putting up stall in the exhibition. Additional information can be given regarding the plantation and detailed cultivation etc. for publicity.
5. Advertizing through Newspaper and Magazine: Various newspapers and magazines reach out to farmers and growers in different parts of the country. The Newsprint can be a very effective medium for publicity.
6. Publicity in Weekly Bazaars: Weekly bazaar is a regular activity in the rural areas. Essential commodities are sold in these markets and almost all the people from the nearby villages visit there. It can prove to be a place for effective advertising and publicity. Loudspeaker announcements, distributing handbills with information on availability of plants can raise the prospects of sale of plants to a great extent.
7. Posters and Blowups: Pasting of posters and blowup charts of plant for sale can be another medium of publicity.
8. Appointing Sale Agents: A large nursery may require large sales network which may include appointing sale agents for different area as per demand. Such agents can work on the basis of commission on sale of plants.

9. Information Brochures: Information brochures regarding the detailed availability of plants, their variety, plantation techniques, care and maintenance of plants, etc can be provided to the prospective customers.
10. Printing Catalogues: Information on plants can be made available by printing catalogues containing detailed technical aspects. Such catalogues can be made available through different nurseries or various input dealer shops.

- **Care to be taken during Sale of Plants**

1. Only those plants which belong to genuine variety and age should be made available.
2. An invoice of bill must be provided to preserve the sanctity of transaction.
3. The rates for sale of various plants in the nursery should be reasonable and meticulously pre-decided.
4. The supply of plants should be made based on the booking by the customers.
5. The sale of plants on credit should be discouraged by the nurserymen.

Apart from above essential points it is also important that the nursery entrepreneur should expand his nursery enterprise based on building relationships with various stakeholders of the nursery enterprise. The after sales service should be made an integral part of nursery supply enterprise to expand the business.

## 10.2.3 Government Regulations and Support for Nursery

Availability of quality planting material is a prerequisite for the success of horticulture development initiatives. The Nursery Registration Act is presently in force in respect of horticulture nurseries only in the States of Punjab, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Jammu and Kashmir, Orissa and Tamil Nadu. A system of monitoring exists for horticulture nurseries in the States of Andhra Pradesh, Assam, Bihar, Goa, Haryana, Karnataka and Kerala while there is no horticulture nursery act in the States of Arunachal Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura and West Bengal. In the absence of any formal system of quality assurance for horticulture planting material under the Nursery Act, an assured development of horticulture cannot take place.

Although agricultural development is enlisted as a state subject in the Indian Constitution, some of the development schemes are initiated by the Central Government. This includes provisions and support for infrastructure for horticulture development. The Horticulture development schemes include support for Fruit cultivation, Vegetables, Flowers production and it invariably includes support for establishment of plant nurseries. The support under these schemes is granted for farmers where the conventionally the use of improved methods of plant propagation is either difficult or is not possible due to various reasons. Various provisions of establishment of Fruit Plant nurseries come under the control of Nursery Act promulgated by different states.

- **Maharashtra Fruit Nursery Act 1969, Regulation 1976 and Amendment 1995**
  The Maharashtra Fruit Nursery Act was promulgated in the year 1969. The regulations under the Act were framed in 1976 and several amendments were made in the year 1995. The Nursery Act is designed for regulation of production of fruit nursery plants and does not include vegetable, flowers and ornamentals seedlings. All fruit nurseries under the Act are required to obtain license for operation of production and sale of fruit plants.

The Act has provisions for,

1. The license fee of Rs 10/- is to be paid along with the application. The renewal fees of Rs 5/- to be paid for renewal of license period.
2. The period of license is valid for 5 years.
3. Visible display of rates of different nursery plants for sale.
4. Record of mother plants, date of plantation, variety, progeny, location, source of mother plants, production and sales.
5. Basis for ascertaining the age of nursery plants
   i. Sowing date in case of seedlings
   ii. Date of planting of cuttings in case of cuttings
   iii. Date of sowing for rootstock and date of grafting for grafted plants
   iv. Date of layering for plants propagated by layering
6. Essentiality of labeling plants for depiction of crop, variety etc.
7. Duties of nursery license holder under the Act.
8. Conditions of appeal for cancellation of grant, renewal, suspension of license.

Any contravention or breach of provisions of the said Act is liable for penalty of Rs 5000/- or imprisonment for six months or both in case of individual offender. But when the offence under the Act is committed by the Company or organization, or representative of the Company, it shall be tried in a competent court of Judicial Magistrate First Class.

- **Quality Standards of Nursery Plants**
  With a view to ensuring availability of genuine and quality planting material, it is essential to adopt quality standards for Horticulture Nurseries to facilitate, promote and monitor production and trade of quality planting materials of horticulture crops which are propagated vegetatively.

**1. Standards for Grafting Operation in Fruit Plants in Nursery**

There are various standards of production different fruit plants for making available for sale to the customers.

| Sr No | Name of Fruit Plant | Type of Grafting | Period of Grafting | Standard for Success Rate for Grafting | Grafting Capacity per man day |
|---|---|---|---|---|---|
| 01 | Mango | Stone Grafting | June-August | 40-50% | 150 |
| | | Softwood Grafting | July-September | 40-50% | 150 |
| | | Approach Grafting | September-February | 60-70% | 75 |
| | | Veneer Grafting | September-February | 40% | 75 |
| 02 | Guava | Tongue Layering | July-October | 60-70% | 150 |
| 03 | Pomegranate | Air Layering | July-October | 60-70% | 175 |
| 04 | Sapota | Softwood Grafting | July | 40-50% | 150 |
| | | Approach Grafting | September-February | 60-70% | 75 |
| 05 | Cashew | Softwood Grafting | Year round | 60-65% | 200 |
| 06 | Sweet Orange and Santra | T-Budding | December | 60-65% | 200 |

**2. Standards for Saleable Age of Fruit Plants**

The standards for saleable age of various fruit plants is mentioned which should be followed by the nursery grower:

| Sr No | Name of the Fruit Plant | Type of Grafting | Minimum Age for Selling the plants in the nursery |
|---|---|---|---|
| 01 | Guava | Tongue Layering | 45 days after removal from mother plants |
| 02 | Pomegranate | Air layering | 45 days after removal from mother plants |
| 03 | Sapota | Softwood and Approach Grafting | 60 days after removal from mother plants when the leaves fully turn green |
| 04 | Santra and Sweet Orange | Budding | 150 days after budding |
| 05 | Cashew | Epicotyl Grafting | 120 days after grafting |

| Sr No | Name of the Fruit Plant | Type of Grafting | Minimum Age for Selling the plants in the nursery |
|---|---|---|---|
| | | and Softwood Grafting | |
| 06 | Mango | Stone Grafting and Wedge Grafting | 1 year after grafting |
| 07 | Coconut | Seedling raising | 9 months after seed germination |
| 08 | Black Pepper | Cutting | 120 days after cutting from mother plant |
| 09 | Other Seed Propagated Plants | Seedling raising | 6 months after germination |

All the plants that are ready for sale in the fruit nursery are required to be labeled to demarcate the plants and their respective variety. The label should include the following information:

- Name of the fruit plant
- Variety of the fruit plant
- License no. of the fruit nursery
- Name of the nursery
- Address of the fruit nursery

### 3. Requirement for Selection of Coconut Seed in Nursery

Coconut being a perennial crop, which has a lifespan of 80 to 100 year, equivalent to the lifetime of a human being, selection of right planting material is of utmost importance in coconut cultivation. Quality seednuts and seedlings are obtained through rigorous selection at various stages.

Some important selection criteria are given below:

- The palm should be free from root wilt and other diseases.
- The palm should be regular bearers with an annual yield of more than 80 nuts per year and minimum copra content of 150g per nut.
- Palm should have at least 30 fully opened leaves at the crown.
- Leaves should have short, strong petioles with wide leaf base firmly attached to the stem. Their arrangement should provide support to the bunch.
- Each leaf axil should have one inflorescence with large number of spikes and one or two female flowers per spike.
- Bunch stalk should be short, stout and strong.
- Palms which produce barren nuts or those shedding large number of nuts in the immature stage should be discarded.
- Collect seednuts from February to May.
- Harvest only fully matured nuts which are at least 11 months old.
- Nuts should not be damaged while harvesting.

- Discard nuts having irregular shape and size.

**4. Standards for Production of Tissue Culture Plants**

The standards have been set by the Department of Biotechnology for production of different tissue culture plants like banana, apple, citrus, black pepper and vanilla.

**Requirements for Banana Tissue Culture Production**

1. All micropropagation and greenhouse facilities should have a changing area between double doors.
2. Laboratory and greenhouse facilities used for production of plantlets shall be maintained free of pests or vectors of banana pathogens.
3. Hygienic conditions shall be strictly observed during micropropagation, potting, planting, irrigating, movement and use of equipment and other laboratory and greenhouse practices to guard against the spread of diseases or pests in the facilities used for banana plant multiplication.
4. The greenhouse must be 'insect proof'. It must be equipped with a double-door entrance, provision for footwear disinfection prior to entering the protected environment and insect proof ventilation screening on intakes and exhaust openings.
5. The material being initiated must be of a notified variety and confirmed identity. It must be duly documented with respect to origin of plant material.
6. All samples of banana varieties being initiated should be tested in an accredited laboratory and be free of Banana Bunchy Top Virus, Cucumber Mosaic Virus, Banana Bract Mosaic Virus, Banana Streak Virus and other endophytic or epiphytic fungi.

**5. Minimum Quality Standards for growing of plants inside greenhouses/polyhouses**

1. Effective sanitation practices for insect and disease prevention must be adhered to.
2. No field-produced banana plants can be grown in the protected environment along with tissue cultured plants.
3. Varieties must be separated by physical barriers such as proper tagging, which will prevent varietal mixture.
4. Before dispatch to the farmers, the tissue-cultured plants growing in the nursery should be tested for the absence of the Banana Bunchy Top Virus, Cucumber Mosaic Virus, Banana Bract Mosaic Virus, Banana Streak Virus and clonal uniformity.
5. If testing performed by an accredited laboratory reveals the presence of banned viruses, fungus or bacteria the tissue-cultured plants should not be dispatched from the premises of the production lab and the entire material should be destroyed.

- **Government Support for Nursery**

  The Central Government and the State Government have different development schemes for developing the supply of nursery plants from nurseries and provide support for development of infrastructure as well as promote exports of plants through nurseries.

**1. Support under State Department Scheme**

All the schemes of the State Government for horticulture development are being implemented through the Department of Agriculture. Some important schemes that are available for the nursery plant production are mentioned herewith:

- Horticulture plantation schemes is in existence since 1990 under the Employment Guarantee Scheme under which the farmers are provided assistance for supply of improved variety of fruit plants for commercial cultivation. Under this scheme the farmers are supplied the fruit plants from various registered and licensed nurseries.
- The horticultural fruit plants are made available from the Government nurseries operating under the Department of Agriculture at Government rates.
- Conversion of local mango, cashew, ber orchards into improved varieties. Support is offered to farmers are growing fruit plants from local planting material for conversion of local stock into improved and high yielding plants.
- Support for establishment of nursery under Private Sector is provided for individual entrepreneurs, registered cooperative societies and quasi-Government Institutes. Here, they are eligible for support to an extent of Rs 20,000/- with a production target of 8000 grafted plants.
- Assistance for rejuvenation of old and senile orchards is especially provided where the orchards are old, poorly managed and have a very poor yield.
- Assistance to nurseries for installation of micro-irrigation system is also provided which is a major scheme of Department of Agriculture for economizing the use of irrigation water.
- Support for establishment of polyhouse and shadenet house for production of quality planting material is provided. This support is provided for both types of (semi-automated and fully-automated) polyhouses and shadenet houses.
- Assistance is also provided to nurseries for mulching the mother trees so as to increase the supply of quality planting material by them.
- Support for multiplication of medicinal and aromatic plants and production of seed material is provided to nurseries.
- Area Extension Scheme for Clonal planting material is available for assistance especially with reference to extension of cashew plantation.
- Assistance to farmers is also extended under the Integrated Spices Development scheme. This scheme supports cultivation of black pepper, clove, ginger and turmeric crops.
- Support for cultivation of vegetables on small scale is available under Mini Kit Vegetable scheme. This scheme extends support for use of improved and hybrid varieties and other aspects of improved technology.

**2. Support for Nurseries under National Horticulture Mission**

Production and distribution of good quality seeds and planting material is an important focus of the National Horticulture Mission. Most of the States have a network of central or state assisted nurseries for producing planting material. For the new areas coming under cultivation of improved varieties assistance is provided to setup new

nurseries under the Public as well as Private sector. These nurseries also provide planting material for the rejuvenation program for old/senile plantations.
Assistance for Infrastructure in nurseries includes the following:

- Proper fencing.
- Mother stocks block maintenance under poly cover to protect from adverse weather conditions.
- Raising root stock seedlings under shadenet house conditions.
- Propagation house, tropical polyhouse with ventilation having insect proof netting on sides and fogging and sprinkler irrigation systems.
- Hardening/maintenance in insect proof net house with light screening properties and sprinkler irrigation system.
- Pump house to provide sufficient irrigation to the plants and water storage tank to meet at least 2 days requirement.
- Soil sterilization steam sterilization system with boilers.

Under the revised guidelines of National Horticulture Mission it has been estimated that a nursery having an area of one ha with the above mentioned facilities would cost Rs.6.25 lakhs. Assistance is provided for setting up a nursery having a minimum area of 1 ha and maximum area of 4 ha with a total cost of Rs. 25 lakhs. The nurseries under Public sector are given 100% assistance and for those under the Private sector 50% assistance is provided as credit linked back end subsidy. Nursery of size of 1 ha will be classified as small nursery and beyond that will be classified as large nursery. Cost norms of nurseries will be @ of Rs. 6.25 lakhs per ha. Each nursery has to produce a minimum 50,000 plants per ha per year of the mandated perennial fruit plant / tree spices/plantation crop through vegetative propagation.

The nurseries are required to ensure supply of quality planting material. In order to ensure supply of quality planting material the planting material must be purchased from the nurseries which are accredited from National Horticulture Board, State Agricultural Universities, and ICAR Institutes. Nurseries are also regulated under legislation in force relating to seeds and planting material. Efforts should be made to establish nurseries at production cluster itself.

## 10.2.4 Nursery Expenditure, Income and Profit Analysis

The nursery enterprise is an important source of employment and income generation. It is important for the entrepreneur to make an estimate of expenditure and probable income during the operation of the nursery. Similarly, it is also beneficial for the entrepreneur to make a nursery production plan of work, manpower and raw material requirement for successful operation of the nursery. The anticipation of income is also an area which requires planning for proper financial appraisal in the nursery business. Proper financial planning of the income, expenditure statements is an essential factor in the success of the nursery business.

Entrepreneurs can use business analysis as a guide for important decisions such as business expansions, financing, marketing strategies, operations planning, and product selection. When applied properly, this information can increase nursery business

profitability, control costs, reduce the risk of business failure, boost employee productivity and job satisfaction, enhance physical efficiency, and improve management professionalism. It can also support the evaluation of costs and returns for individual products to determine a more profitable product mixture. Financial analysis can assist in identifying some common problems in wholesale plant nurseries such as low output, slow crop growth or poor pricing, excessive costs, waste or overuse, poor cash flow, overcapitalization or undercapitalization, and imbalanced debt structure.

## 1. Components of Expenditure in Nursery

The establishment of plant nursery requires an investment to be made that comprises of two major components namely Fixed Capital and Working Capital components.

- **Fixed Capital Components**

The fixed capital comprises those components where one time capital investments are required to be made. This comprises:

| Sr No | Particulars | Quantity | Rate in Rs/unit | Year I | Year II | Year III |
|---|---|---|---|---|---|---|
| 01 | Fencing | 400 sq.m. | 40 | 16000 | 0 | 0 |
| 02 | Workshed | 20 sq.m. | 500 | 10000 | 0 | 0 |
| 03 | Mother Plant Block | 6000 sq.m. | 5 | 30000 | 5000 | 4000 |
| 04 | Irrigation with pipeline | 10000 sq.m. | 13.5 | 135000 | 4000 | 4000 |
| 05 | Office cum Store | 27 sq.m. | 500 | 13500 | 0 | 0 |
| 06 | Shadenet House | 400 sq.m. | 275 | 110000 | 0 | 0 |
| 07 | Polyhouse | 200 sq.m. | 500 | 100000 | 0 | 0 |
| 08 | Mist Chamber | 15 sq.m. | 250 | 3750 | 0 | 0 |
| 09 | Polytunnel | 150 sq.m. | 250 | 37500 | 0 | 0 |
| 10 | Land preparation, nursery beds, internal roads, pathways, potting yard | 2000 sq.m. | 10 | 20000 | 0 | 0 |
| 11 | Water Storage | 1 unit | - | 25000 | | |
| | Total | | | 500750 | 9000 | 8000 |

The above components are taken into consideration for establishment of plant nursery on one hectare area. These are required to be made once like land structures as mentioned above. This component is most capital intensive and hence requires careful planning and identification of plants which are required to be produced and made available for sale.

- **Working Capital Components**

  Working capital is the amount used by a business unit to meet out its daily requirements. It is also known as circulatory capital. The amount spent on payment of wages, salaries, stock purchased, raw material purchased, transportation etc. are all examples of working capital.

  The working capital includes subcomponents as,

**I. Labour :** The labour is required for the nursery for carrying out various skilled and unskilled operations like, seed bed preparation, sowing, watering, weeding, pruning, bagging, media preparation etc. A nursery on 1 hectare area producing one lakh saplings and grafts requires labour as follows:

**Nursery Labour Requirement**

| Sr No | Crop | Operation | Physical Production Target | No. of labours required | No. of days required | Total mandays of work | *Cost of labour in Rs. |
|---|---|---|---|---|---|---|---|
| 01 | Mango | Bag filling & Shifting | 20000 | 20 | 31.1 | 213.2 | 21320 |
| | | Grafting | | 10 | 10 | 100 | 10000 |
| | | Stone sorting, treatment, sowing, seedling removal | | 26 | 18 | 94 | 9400 |
| 02 | Guava | Layering,Removal & bag filling | 20000 | 9 | 10.33 | 46.67 | 4667 |
| | | Mother plants care & Maintenance | | 14 | 81.5 | 233 | 23300 |
| | | Mound layering | | 8 | 10 | 80 | 8000 |
| 03 | Pomegranate | Layering, Removal of gutti and bag filling | 25000 | 10 | 16 | 80 | 8000 |
| | | Weeding, irrigation, peticides application in mother stock | | 11 | 16.7 | 44.2 | 4420 |
| | | Drip maintenance in mother stock | | 4 | 3 | 12 | 1200 |
| | | Air layering(gutti) | | 5 | 5 | 25 | 2500 |
| 04 | Fig | Gutti removal, bag filling | 5000 | 9 | 9.33 | 42.67 | 4267 |
| | | Mother plants care & Maintance. | | 11 | 15.5 | 33.9 | 3390 |
| | | Drip & maintenance | | 2 | 2 | 4 | 400 |
| | | Guti layering | | 4 | 10 | 40 | 4000 |
| 05 | Aonla | Sowing in RT trays & bag filling | 5000 | 6 | 3.58 | 11.33 | 1133 |
| | | Mother Plants Care & Maintenance | | 8 | 4 | 10 | 1000 |
| | | Drip & maintenance | | 2 | 2 | 4 | 400 |
| | | Budding 2000 seedling | | 4 | 5 | 20 | 2000 |
| 06 | Drumstick | Bag filling, seed | 10000 | 6 | 10.41 | 22.92 | 2292 |

| Sr No | Crop | Operation | Physical Production Target | No. of labours required | No. of days required | Total mandays of work | *Cost of labour in Rs. |
|---|---|---|---|---|---|---|---|
| | | sowing | | | | | |
| | | Mother plants care | | 19 | 54.5 | 126 | 12600 |
| | | Drip & maintenance | | 4 | 4 | 16 | 1600 |
| 07 | Custardapple | Sowing & seedling transplantation in polybags | 5000 | 8 | 6 | 24 | 2400 |
| 08 | Lime | Sowing & seedling transplantation in polybags | 5000 | 13 | 8 | 33.87 | 3387 |
| 09 | Teak | Stump plantation & bag filling | 5000 | 3 | 2.44 | 7.34 | 734 |
| 10 | General Nursery | Bed preparation nursery | | 8 | 38.75 | 155 | 15500 |
| | | Care of seedlings & grafts in beds | | 18 | 61.9 | 220.8 | 22080 |
| | | Ornamentals, cuttings prep., Irrigation | | 14 | 88 | 206 | 20600 |
| | | Maintenance, trimming, irrigation, weeding | | 17 | 61.625 | 252.5 | 25250 |
| | TOTAL | | 100000 plants | 273 | 588.665 | 2158.4 | 215840 |

*Labour rate 100/- per man-day

**II. Raw Material Requirements:** Raw material inputs like media, polybags, fertilizers, manures, pesticides and consumables like labels, stationery, electricity and telephone are required for production of seedlings. The following chart illustrates the raw material requirement for 1 lakh plant nursery.

| Sl. No. | Items | Quantity | Rate | Total |
|---|---|---|---|---|
| 1 | Manures and organic fertilizers | 10 brass | 1000 | 10000 |
| 2 | Riverbed soil | 40 brass | 1000 | 40000 |
| 3 | Seeds | - | - | 5000 |
| 4 | Plastic material for Polybag (15cmX10cmX150Gauge), strips etc. | 250 kg | 100 | 25000 |
| 5 | Fertilizers for saplings and mother plants | 500 kg | 12 | 6000 |
| 6 | Water charges | -- | -- | 2000 |
| 7 | Electricity | -- | -- | 10000 |
| 8 | Plant Protection | -- | -- | 5000 |
| 9 | Label and stationery | -- | -- | 10000 |
| 10 | Maintenance & Supervision | -- | -- | 20000 |

| Sl. No. | Items | Quantity | Rate | Total |
|---|---|---|---|---|
| 11 | Publicity & Advertisement | -- | -- | 10000 |
| 12 | Interest on Capital @ 12% | -- | -- | 72960 |
| | **Total** | | | 215960 |

Total Capital requirement for establishment and operating nursery for one year is sum of Fixed Capital and Working Capital as stated above which works out to Rs 9,32,550.

**2. Nursery Income**

The nursery enterprise can have various sources of income like from sale of saplings, grafts, vegetable seedlings, potted plants, bagged plants and ball seedlings, planting material like seeds, corms and bullets etc. It can additionally have various other raw material and equipments for sale like pots, bags, pruning and grafting implements etc. However for the illustration of expenditure and income in the above example of Fruit Plants Nursery the major income will be from the sale of seedlings and grafts. The details of income can never be 100 per cent of its production capacity. For example if the production capacity is 100000 plants then it is assumed that the sale of the plants and actual realization of the income will be 60% in the first year and it will grow further to maximum 80 to 90%. Following chart shows the realization of income from the sale of different plants:

| Sr No | Name of Seedlings/Graft | Production Capacity in No. | Rate in Rs per plant | I Year Sales Realization (60% ) | II Year Sales Realization (70% ) |
|---|---|---|---|---|---|
| 01 | Mango | 20000 | 35 | 420000 | 490000 |
| 02 | Guava | 20000 | 25 | 300000 | 350000 |
| 03 | Pomegranate | 25000 | 15 | 225000 | 262500 |
| 04 | Fig | 5000 | 22 | 66000 | 77000 |
| 05 | Aonla | 5000 | 50 | 150000 | 175000 |
| 06 | Drumstick | 10000 | 5 | 30000 | 35000 |
| 07 | Custardapple | 5000 | 5 | 15000 | 17500 |
| | | | | 1206000 | 1407000 |

The net income from nursery enterprise during the first year will be gross income minus total expenditure during the first year which will be Rs 2,73,450 in the above case.

The income source can be additionally extended further by production and sale of vegetable seedlings and ornamental plants. Further the nursery enterprise can also provide the plants in bulk to small nurseries in the distribution value chain of nursery plants sale. Such add on activity can further help to expand the nursery business. There are also newer concepts like sale of plants based on the age of plants. For example if the mango plants are made available for sale during the first year then the cost would be Rs

30 per plant, however if the mango grafts are raised in the bigger polybags and are tended to attain a height of 5 feet and above the cost of such plants increases. Thus the unsold plants can be raised and maintained for future sale and transplanted into larger bags to accommodate growth of roots. This becomes an additional source of income. The sale of such plants is dependent on the height of plants. Big nurseries in and around the urban townships have now started sale of grafts and seedlings of plants based on age and height that are in demand. This type of innovative raising of plants attract the farmers because advanced age and height of plants saves the crucial 2 to 3 years of gestation required before the fruit orchard comes for bearing.

Other source of income can be from realization of commission, consultancy fee, subsidy, donation and minor sale of weedgrass, fuel wood etc from nursery.

### 3. Records Maintenance for Sale and Income

The nursery should maintain the record of mother plants illustrating both the rootstock and the scion trees as well. Additionally it should also to maintain separate record of production of grafts and seedlings and sale of plants. The formats of maintaining the records are mentioned below and the illustrated formats are as per the provisions and directions of Maharashtra Fruit Plants Nursery Act 1969.

Source of Rootstock and Scion material in nursery

| **Land Survey No of Mother Plants** | **Name of Fruit Plant and type/variety** | | **Tree number allotted to the fruit tree** | |
|---|---|---|---|---|
| | Rootstock | Scion material | Rootstock | Scion |
| | | | | |

Record of Production in Nursery

| **Name of Fruit Plant and type/variety** | **Tree number allotted to the tree** | | | |
|---|---|---|---|---|
| | Rootstock | Scion | No of Grafts produced | No. of plants ready for sale and plantation |
| | | | | |

Record of Sale of Plants from Nursery

| **Date of Sale** | **Name & Address of person to whom plants are sold** | **Record of source of rootstock and scion** | | | |
|---|---|---|---|---|---|
| | | Rootstock number | Scion number | Rate of Sale per plant | Remarks |
| | | | | | |

Apart from the record for the sale and production of nursery plants it is also recommended that the nursery entrepreneur maintain record of expenditure in the nursery which is called book keeping.

Book keeping is one of the functions of financial accounting. Book keeping entails maintaining proper records and books for recording complete details of transactions made during the course of business. Business transactions can be classified into several major activities/groups e.g. sales, purchases, assets, etc. Separate books for recording transactions pertaining to these activities are maintained. Details of the transactions are record into respective head. This exercise is called Book keeping.

It is advisable to maintain books of accounts for the following reasons:

- They provide up-to-date information about the nursery business.
- They reflect the outcome of transactions made during the period under review.
- They give information about the state of affairs of the business at regular intervals.
- They help governments and other authorities to decide about the incidence of various taxes.
- They help to analyze the performance of the nursery business.
- They help to compare the performance of several business firms.

Various records of expenditure and income are recorded in different book records as follows:

1. **Purchase Book**: In the purchase book, all transactions pertaining to purchases on credit or cash are recorded. Transactions of purchase returned are also recorded here separately.

| Date | Party's name | Bill No. | Ledger Folio | Item name | Quantity | Rate | Amount | Terms |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Total | | | | | | | |

2. **Sales Book**: In the sales book, all transactions pertaining to credit or cash sales are recorded. Transactions of sales returned are also recorded separately.

| Date | Party's name | Bill No. | Ledger Folio | Item name | Quantity | Rate | Amount | Terms |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Total | | | | | | | |

3. **Ledger**: All accounts involved in the transactions recorded in the journal or its subsidiary books are maintained here, and necessary posting is made.

| Debit Side | | | Name of Account | | | | Credit Side |
|---|---|---|---|---|---|---|---|
| Date | Particular | Folio No. | Amount | Date | Particular | Folio No. | Amount |
| | | | | | | | |

It may be noticed from the format that a ledger account has two sides: debit side (lefthand side) and credit side (right-hand side). Each side is further divided into four sections, viz. `Date', `Particulars', `Journal Folio Number' and `Amount'.

(i) Date: In this column, the date of a transaction as entered in the journal book from where the entry is brought to the ledger account is mentioned.

(ii) Particulars: In this column the name of the account in which the corresponding credit or debit (under the double entry principle) is mentioned.

(iii) Journal Folio Number: In this column the page number of the journal book or subsidiary book from where the transaction is brought to the account is mentioned.

(iv) Amount: In this column the amount, with which the account is debited or credited, is mentioned.

**4. Cash Book**: The cashbook is a subsidiary book of the ledger where the account of `cash' is maintained. Transactions involving 'petty cash' are also posted here separately. The 'Cash Book' is nothing but a cash account. Like other asset accounts, this account is also required to be mentioned in the ledger. However, because of the multiplicity of cash transactions and for convenience, cash account is not maintained in the general ledger but maintained as a separate account and named as cash book.

| Debit Side (Payments) | | | Name of Account | | | Credit Side (Receipts) | |
|---|---|---|---|---|---|---|---|
| Date | Particular | Journal Folio No. | Amount | Date | Particular | Journal Folio No. | Amount |
| | | | | | Closing Balance | | |
| | TOTAL | | | | TOTAL | | |

**5. Bank Book**: The bankbook is a subsidiary book of the ledger where the account of the bank is maintained. A bank book is nothing but bank account required to be maintained in ledger. Since the transactions involving bank are increasing, it is convenient and proper to keep a separate bank account where all transactions involving bank are posted. This account, therefore, is separately maintained and named bank book. All rules of making posting in other ledger accounts are applicable to this account as well.

| Debit Side (Withdrawals) (Deposits) | | Name of Account | | | | Credit Side | |
|---|---|---|---|---|---|---|---|
| Date | Particular | Journal Folio No. | Amount | Date | Particular | Journal Folio No. | Amount |
| | | | | | Closing Balance | | |
| | TOTAL | | | | TOTAL | | |

**6. Stock Register**: This is a register where the movement of stock is maintained.

| Date | Particulars | Sales Book/Purchase Book Folio No. | Receipts | | Issues | | Balance | |
|---|---|---|---|---|---|---|---|---|
| | | | Quantity | Value | Quantity | Value | Quantity | Value |
| | | | | | | | | |

The stock register is very similar to stock account. It tells us about the actual closing stock available with the business to help the owner physically verify and place further orders.

- **Profit Analysis and Financial Ratios**

A nursery enterprise requires capital investment to establish various fixed capital assets as well as working capital. This capital investment requires arrangement of finances from a financial institution like bank and from personal contribution or from friends and relatives. The capital or finance raised from the bank or other lenders is at a cost which is generally called the interest. In order to verify if the nursery enterprise is economically viable and profitable various financial ratios are taken into consideration. These ratios help the lenders to analyse the viability and profitability of the nursery enterprise. Some important financial ratios are mentioned below:

**Return on Investment:** A nursery enterprise collects funds from two sources for long-term investment. The amount collected is used to create assets and for day to day operations this generates surplus for the enterprise. Surplus is required to be distributed to the contributors of the funds. Interest is the compensation given to contributors of borrowed capital, and net profit and depreciation are given to the owner of the enterprise. Though depreciation reduces profit, it is a non-cash provision made to recover the original investment. Thus, the cash profit of the enterprise is increased to the extent of depreciation.

The total surplus generated by the project over its entire life has to be averaged to find out yearly return. This yearly return, when calculated on the total investment needed

for the project, tells us about the return on investment. This ratio tells us the surplus-generating capacity of the investment.

One must know the return on investment (RoI) to be generated so as to make the nursery project viable. The simple rule to assess the viability is that the RoI must be greater than the cost of investment.

Let us first consider the term investment cost. Investment comprises two major components:

(1) Borrowed capital (Normally taken as loans from banks and financial institutions)

(2) Own capital (Normally contributed by entrepreneurs)

It is simple to calculate the cost of borrowed capital. Any borrower has to commit the fixed service charge, i.e. interest at the time of sanctioning loan. Nursery enterprise is financially viable only when the RoI is greater than the cost of investment.

**Debt Service Coverage Ratio (DSCR):** When a loan is taken for running a nursery enterprise, the loan must be repaid with interest. For this, a nursery enterprise must generate surplus, adequate to meet repayment obligations. The DSCR is a tool used to determine this.

The Debt service coverage ratio is the single most important parameter to determine the ability of the nursery enterprise to repay term-loan in the form of principal and interest. A financial ratio, which measures the capacity of the enterprise to meet term-loan-cum-interest and other long-term commitments/obligations, is called Debt Service Coverage Ratio (DSCR). A DSCR of value 1, means that the enterprise can generate cash just enough to meet all the (term-loan-and-interest) obligations. The term lender prefers a project which will generate enough cash surplus to meet the dues even if there is some slide back in the performance of the project. A DSCR of 1.7 should be the minimum value of DSCR in a viable nursery enterprise. Higher the DSCR value, better the financial viability of a project.

Its formula is:

$$\text{DSCR} = \frac{\text{Net profit + Interest (on long term loans) + Tax}}{\text{Interest (on long term loans) + principal loan}}$$

A project is considered financially viable if the cumulative DSCR during repayment Period is above 2:1

**Internal Rate of Return (IRR):** The internal rate of return on an investment or project is the annualized effective compounded return rate or discount rate that makes the net present value of all cash flows (both positive and negative) from a particular investment equal to zero. In more specific terms, the IRR of an investment is the interest rate at which the net present value of costs (negative cash flows) of the investment equal the net present value of the benefits (positive cash flows) of the investment.

Internal rates of return are commonly used to evaluate the desirability of investments or projects. Higher the internal rate of return of a project, more desirable it is to undertake

the project. The project with the highest IRR would be considered the best in case of comparison between projects with all other equal factors.

**Break-Even Point (BEP):** This is another important tool. The break-even point is the level of activity where the total contribution is equal to the total fixed cost.
Contribution is the excess of sales over variable cost, i.e.

**Contribution = Sales - Variable Cost**

Contribution is a type of surplus that is generated in a business after paying the variable costs fully from the sales revenue.

The break-even point is the point of activity where all cost (variable as well as fixed) is recovered from the sales values. At the break-even point the nursery business, therefore, does not make profit or loss. When any nursery business is below the break-even, it incurs loss. The business makes a profit above the break-even value. So, when the business fully pays for the total fixed cost from contribution, the unit can be said to have achieved the BEP. When contribution fully pays for fixed cost, the business is said to have achieved break-even. Several formulae have been evolved to calculate break-even:

1. BEP = $\frac{\text{Total Fixed Cost}}{\text{Contribution per unit of activity}}$ (In quantum of activity)

2. BEP = $\frac{\text{Total Fixed Cost}}{\text{Contribution per unit of activity}}$ X Sale price per unit (In Sales value)

The BEP indicates the risk involved in a project. Normally, nursery enterprises achieving breakeven sales level at higher capacity utilization are considered to be more risky, while those achieving it at a lower level of capacity utilization are safer. The thumb rule is lowering the break-even betters the proposition.

**Debt-Equity Ratio:** This ratio indicates the extent to which the funds of promoter are leveraged to procure loans. The formula of DER is:

$$\frac{\text{Total long-term debt}}{\text{Total promoter's fund (includes subsidy)}}$$

A higher debt equity ratio indicates more risk due to a higher fixed cost of interest. The BEP of such enterprises will go up. It would be desirable to maintain the DER at a judicious level, say, varying between 2:1 and 3:1 for any nursery enterprise.

- **Budgeting in Nursery Enterprise**

It is important to perform budgeting of expenditure and income in nursery enterprise to make the nursery business economically viable and profitable.

Budgeting is the process of making a logical estimate of probable expenditure heads like fixed assets during the establishment phase and of operational costs during subsequent years and also perform estimate of income from various sources like sale of

plants, consultancy or sale of various nursery products. This activity of anticipating the probable expenditure and income heads during a financial year is called budgeting.
Planning of probable operational expenditure like raw material and labour requirement should be done well in advance to make the nursery business a profitable venture. During the planning process it is essential to make an estimate of major heads of expenditure and allocate the funds for the expenditure under various heads. There should be a logical balance between the need of expenditure on raw material and the labour requirement of a nursery enterprise.

Any business venture requires proper maintenance of accounts on expenditure and income. The income from sale of plants in a nursery business is unreliable and fluctuating depending upon various market factors like demand, season, satisfactory monsoon, etc. However the expenditure under various heads like the production cost is a necessity and has to be made irrespective of the demand. Hence expenditure often precedes the income in the early stages of the venture. Over a period of time as the enterprise matures, the sales of plants picks up and the income starts rising. At such a stage, judging and analyzing whether the nursery enterprise is a profitable or a loss making unit becomes difficult without accounting of expenditure and income. Failure of anticipating the working capital expenditure might lead to excessive costs. Budgeting facilitates analysis of the heads on which funds must be spent on priority basis and those which can wait or do with lesser funds.

By and large, it is necessary to balance various heads of expenditure. Some ratios of expenditure on raw material and labour must be worked out. Such ratios can help the nursery entrepreneur to anticipate future requirement of funds and thus efficiently plan the future expenses. For example, the ratio of expenditure on raw material and labour should be preferably 3:1 or 2:1. Budgeting is thus an essential exercise in a successful and profitable nursery enterprise.

- **Future Projection of Nursery Enterprise**

For a nursery enterprise to be a profitable venture, meticulous planning is required. This process not only includes the production and supply of grafts and seedlings but also the strategic marketing efforts in order to reach maximum number of plant lovers.

It is of significance especially in perennial horticultural crops which has a long gestation period and effects are known only in later stages. In the existing infrastructure, there are just over 100 big nurseries. A number of Government nurseries also exist in different states. Planting material is also being produced by the public and private nurseries which also play important role to meet the requirement of the growers. At present the number of small and medium scale nurseries is over 6300. Presently only 30-40% demand of planting material is being met by the existing infrastructure initiatives. The Working Group on Horticulture and Plantation Crops for the Eleventh Five Year Plan has projected the total requirement of planting materials of fruits, coconut, cashew, black paper, tree spices, areca-nut etc. as 2000 million by the year 2012 at a modest growth rate of 4% per annum. In the segment of fruit crops alone, the projected demand for the planting material may increase more than 8.5 million grafts by the year 2011-12. Supply of such a huge quantity of disease free, true to type quality planting material is a

big challenge. None the less, the nursery entrepreneurs must be vigilant about the region which demands the respective planting material.

Most of the nurseries have a huge demand and have been observed to be running with operating profits successfully. It is estimated that less than 10 per cent of nursery established face losses during the initial three years period. This results because of poor management skills in nursery enterprise and lack of marketing efforts.

It would therefore be wise to carry out market survey to anticipate demand of various plants in the coming season before production of plants in a nursery enterprise begins.

## 10.2.5 Enterpreneurship Development through Nursery

Nursery is an important enterprise which creates sizable employment opportunities for the rural masses. There are various types of business areas under horticulture nursery which provide employment. The areas under horticulture nursery may comprise production of seeds, seedlings, grafts, potted plants, ball plants; providing plants for aesthetic purposes in landscaping or event management program on rental basis; sale of plants to retail nurseries; starting plant libraries; providing vegetable seedlings; ornamental plants and planting material; medicinal and aromatic plants; tissue culture plants providing tissue culture plants through hardening units; and landscape gardening and consultancy.

- **Qualities in an Entrepreneur Required for Horticulture Nursery Enterprise**

A nursery entrepreneur is defined as a person in effective control of commercial undertaking who undertakes a nursery business or an enterprise. Any economic activity relating to nursery also generates wage-employment for others and this is called entrepreneurship**.** The people who practice entrepreneurship are called entrepreneurs**.** The qualities required for a nursery entrepreneur are as follows:

1. Risk-taking is an important aspect of entrepreneurial life. Entrepreneurs are calculated risk-takers. It may involve several processes like understanding the situation, gathering information, assessing the available resources, setting up goals for nursery production, testing capabilities and modifying the goals based on experience.
2. Entrepreneurs perceive opportunities quickly, synthesize the available information and analyze emerging patterns that escape the attention of others. They are people with a vision, capable of persuading others such as customers, partners, lenders, employees and suppliers to see the opportunity, share it and support it. After spotting the opportunity, they evolve a strategy to find a creative solution to the problem or need.
3. Entrepreneurs have a strong desire to hit new goals. An entrepreneur does not rest until the goal is achieved.
4. Entrepreneurs are innovative and can convert adversities into opportunities.
5. Entrepreneurs seek out experts for assistance rather than friends and relatives.

6. Entrepreneurs take immediate feedback on performance and prefer prompt and accurate data, irrespective of whether it is favorable or not.
7. Entrepreneurs are achievement-driven people who are optimistic even in unfamiliar situations.
8. A successful entrepreneur has an open mind. If the situation demands, they do not hesitate to change their decisions, but only after weighing its pros and cons.
9. Most successful entrepreneurs set goals for themselves and plan to achieve them in a prescheduled time frame.
10. A successful entrepreneur can influence others and motivate them to think and act in his way.

- **Role of Nursery Entrepreneurship**

The nursery enterprise helps in providing plants and planting material and related processes that indirectly help the national economy. The nursery enterprise also assists in gaining a more balanced financial development as the business flourishes both in urban and rural sector. It reduces the migration of labor from rural to urban areas in search of employment. It helps in empowering people by providing increased community participation. Most importantly the nursery enterprise contributes to national economy by providing employment opportunities for the skilled and unskilled workers.

- **Type of Nursery Enterprises**

Different types of nursery enterprise can provide avenues of employment and availability of plants through sale. It includes the following types nursery based enterprise:

1. Fruit Plants Nursery
2. Ornamental Plant Nursery
3. Flowering Forest Nursery
4. Vegetable Nursery
5. Medicinal and Aromatic Plants Nursery
6. Retail Nursery
7. Wholesale Nursery
8. Plant Library
9. Landscape Gardening Consultancy
10. Plant Tissue Culture Nursery
11. Secondary Hardening Nursery

1. **Fruit Plants Nursery:** The fruit plants nursery produces fruit plants and grafts of improved varieties for plantation in different agro-climatic zones. They produce the planting material of different varieties in different regions, as per demand. It includes different fruit grafts and seedlings for sale as per demand and preference of farmers.
2. **Ornamental Plant Nursery:** The ornamental plant nursery provides various plants of aesthetic value for the urban dwellers, institutes and various establishments. The

ornamental plant nursery can produce various plants like flowers plants, indoor and outdoor plants, flowering tree seedlings, flowering shrubs, and flowering creepers for various customers generally in urban centers, cities and townships especially for bungalows, establishments and institutes. The ornamental nursery supplies plants for landscaping of the terrain. This nursery also includes production and supply of different lawns and grasses for beautification purposes.

3. **Flowering Forest Tree Nursery:** Various flowering forest trees are produced in nursery. The forest nurseries have a mandate of production of various forest trees for afforestation program in reserve areas. Most of these plants are not available for sale from forest department. However some flowering tree plants are in great demand in urban development areas and townships. These flowering trees are also used for avenue plantation on the sides of roads and pathways.
4. **Vegetable Nursery:** There is huge demand of vegetable seedlings during kharif, rabbi and summer season. Most of the farmers prefer planting readily available hybrid seedlings of various crops like chilli, brinjal, tomato, capsicum, marigold etc. The readymade seedling for transplantation saves time and labour for the vegetable growers. Most of the vegetables seedlings are made available to farmers during the growing season. The vegetables seedlings are grown in propagation trays by the vegetable nurserymen for the farmers. The vegetable seedlings require from 18 days to 40 days time for preparation of seedlings for supply to the farmers.
5. **Medicinal and Aromatic Plants Nursery:** There is increasing awareness regarding advantages of use of various medicinal and aromatic plants. These plants are in huge demand from various growers who produce medicinal or aromatic plants for different pharmaceutical industry. The *Aloe vera*, sarpagandha, ashwagandha, Asparagus, adulsa, *Vinca rosea*, senna, *Bacopa monieri*, aonla, hirda, behda, safed musali, mint, Basil, Citronella, lemongrass, khus etc are important medicinal and aromatic crops which are processed for their medicinal and aromatic value. Many plants like mint, citronella, lemongrass, safed musali are grown as commercial plantation by the farmers. Such medicinal and aromatic plants are traded for their high value oils and tuber powder.
6. **Wholesale and Retail Nurseries:** The wholesale nurseries prepare seedlings and grafts of various ornamentals and fruit plants on large scale and are supply them to different small retailer nurseries. Such retail nurseries procure these plants from the wholesale nurseries in bulk quantities.
7. **Plant Tissue Culture and Secondary Hardening Nurseries:** The production tissue culture plant is called micropropagation. Most of the tissue culture plants are highly sensitive to environmental stress and different diseases and pests. Such plants are therefore required to be hardened in shade net house conditions before they are planted in the field. The rearing of such tissue culture plants at secondary stage is called Hardening and the nurseries undertaking such hardening of tissue culture plants at secondary stage before plantation are called Secondary Hardening Nurseries. It is an important source of employment for entrepreneurs.

8. **Plant Libraries:** The plant library is a concept similar to a book library where the plants are supplied to various landscapers and event managers organizing cultural, social and other events, gatherings and functions on a rental basis.
   Similarly different office establishments require ornamental plants, potted plants and bouquets of flowers to be displayed on desktops and used in office beautification on rental basis. Such a system of supply of ornamental plants to various office establishments generates employment opportunities for entrepreneurs and horticultural nurserymen.
9. **Landscape Gardeners:** Landscape gardener is a master gardener who supplies and undertakes plantation of flowering trees, ornamental plants, shrubs, bushes etc for beautification of surroundings, terrain or landscape based on shape, slope, location, type of soil etc. The landscape gardeners provide basic groundwork for plantation of various ornamental trees and plants around the buildings, office establishments, premises etc. Some gardeners also provide complete gardening establishment expertise on turn-key basis after careful survey and assessment of site and terrain.

- **Risk Analysis in Nursery Enterprise**

The nursery enterprise can be run successfully provided the raw material, labour, capital requirement, planning of expenditure and income, and knowledge of market are carefully taken into consideration. Various factors that can lead to losses in a nursery enterprise and factors which increase the profitability in nursery enterprise are mentioned as follows:

**Under-utilization of Capacity:** The production of nursery plants below the total production capacity leads to poor returns. This may happen despite availability of mother plants and other raw materials.

**Untimely availability and Sale of Plants:** Many times the plants and grafts produced in nursery are not according to the time of demand. Plants are ready for sale during other parts of the year when usually the plantation season is over and the demand of plants drop considerably. This can lead to poor sale of plants even though the plants are made available.

**Production not as per demand:** Sometimes the plants produced are not as per the demand of plants. The demand for plants may differ from actual production. This leads to balance stock of plants over an increased period of time. For example Ratna or Alphonso mango grafts are prepared when the demand for Keshar mango exists or Aarakta pomegranate plants are prepared when the demand for Bhagwa variety plants is more. This may lead to discrepancy in sale or subdued sales.

**Increasing competition:** Many times sale and availability of non-descript plants from nurseries of other states and competing nurseries can lead to poor sales from ones' nursery. For this careful marketing strategy to overcome the competition is necessary.

**Poor recovery of credit sales:** In a nursery enterprise, unrealistic and higher sale of nursery plants on credit lead to poor recovery of sales realization. It requires considerable effort of time and money to make credit recovery. This is an important factor that needs to be considered for selling the nursery plants on credit.

**Increasing cost of labour and raw material:** Poor planning and anticipation of labour and inputs may lead to higher cost of labor and raw material. The unavailability of labour and increasing cost of various nursery inputs like riverbed soil, plastic material, moss etc can also cause losses.

**Poor technical knowledge:** Nursery enterprise requires sound technical knowledge and skills for production of seedlings and graft as per demand. This requires adequate training and professional knowledge of production technology of nursery plants.

- **Profitability in a Nursery Enterprise**

Nursery enterprise is based on assumptions of demand of plants and availability of various production inputs like raw material and labour. The enterprise is therefore dependent on considerable risk factors as stated above. Various other risk factors like scarce or shortfall in rains, deviation in Government subsidy schemes, higher costs and poor income and increasing illegal activities pertaining to sale of nursery plants affects the profitability of a nursery enterprise.

Some important points to be considered for bringing nursery enterprise into a profitable venture are as follows:

1. Production of plants in a nursery is a commercial business activity and is to be seen from the point of view of economics of expenditure and returns.
2. There is need to balance the technical aspects and practical feasibility of production and sale of plants in a nursery.
3. The nursery enterprise may not start yielding profits from the first year onwards but may require minimum five to six years for planning and execution of operations and bringing the nursery business into profit.
4. Maintenance of records of expenditure and income need to be carried out regularly to ascertain the profitability or loss in the business. A critical analysis of such record may provide solution for overcoming the problem of poor returns.
5. Monitoring of daily activities in nursery activities can provide immediate answers to the problems faced during the production and sale in nursery.
6. There needs to be coordination amongs three important aspects of nursery enterprise which are production of plants, rearing of plants and sales of plants.
7. Increasing the sales through aggressive marketing, publicity and advertisement in newspaper, magazines and other mass media, participation in exhibitions can enhance the sales in nursery enterprise to a considerable extent.

## 10.3 Glossary

**Advance Booking:** A priority booking of plants for timely supply

**After Sales Service:** A service rendered after sale and supply of plants for the care of plants

**Aggressive Marketing**: A strategic marketing that is thrust upon buyers so as to compel them to purchase the respective brand amongst its competitors.

**Break Even Point:** The break-even point is the point of activity where all costs like variable as well as fixed costs are recovered from the sales values.

**Capital expenditure:** Major component of expenditure incurred for establishment.

**Credit:** A loan raised from bank or debtors or contributors that is required to be paid back over a period of time at a specified cost that is interest

**Debt Service Credit Ratio:** A financial ratio, which measures enterprise capacity to meet term-loan-cum-interest and other long-term payment obligations.

**Demand Survey:** A survey conducted in an area prior to supply to ascertain sales.

**Fixed Capital:** Expenditure on major structures like shade net house, polyhouse, irrigation, fencing, etc to be incurred once during establishment phase.

**Hardening Nursery:** A nursery where secondary hardening of plants is done before sale

**Internal Rate of Return**: The rate at which the net present value of costs (negative cash flows) of the investment equal the net present value of the benefits (positive cash flows) of the investment.

**License:** An authorization granted by Government to produce and sell fruit plants to the farmers.

**Maharashtra Fruit Nursery Act 1969**: An act governing the rules and regulations for operation of fruit nursery in the state of Maharashtra

**Mist Chamber**: A structure where misting and fogging is done for propagation.

**National Horticulture Mission:** A Union Government mission-based assistance program for development of horticulture in different states.

**Plant Library:** A nursery production house supplying plants on rental basis

**Polyhouse:** A structure for rearing plants in controlled environment.

**Polytunnel:** A low cost tunnel type structure for growing seedlings.

**Retail Nursery**: A nursery selling plants directly to customers

**Return on Investment**: The total surplus generated by the project over its entire life calculated on total investment when averaged to find out yearly return is the return on investment.

**Risk Bearing Ability:** An ability to invest on an economic activity based on assumption that the activity will generate adequate income.

**Sales Agent:** A person selling plants on commission basis

**Standards:** Minimum quality parameters which are required to be adhered for production and supply of fruit plants

**Under Utilization of Capacity**: Production of plants in a nursery lower than its stipulated capacity.

**Working Capital:** Expenditure to be incurred on raw material like soil, media, manure, plastics, moss, labour, etc required for day to day production of plants.

## 10.4 Points To Remember

- Capital investment component of nursery includes the cost of land, infrastructure, building construction, irrigation system and raw material.

- The various types of horticulture nursery includes, fruits, vegetable, flower, ornamental, medicinal and herbal, and forest plant nurseries.

## 10.5 Self Check Questions

1. What is the capital component of investment for establishment of a nursery enterprise?
2. Enumerate the steps to be taken for publicity and advertisement of nursery.
3. What are the points to be considered for expanding the nursery business?
4. What are the major provisions of the Maharashtra Fruit Nursery Act, 1969?
5. Enumerate the standards for production of different fruit plants.
6. What are the major components of expenditure in a nursery?
7. What is the Internal Rate of Return and Break Even Point?
8. Enumerate the types of record keeping and types of book keeping for maintenance of accounts for a nursery enterprise.
9. List out the factors that can lead to losses in a nursery enterprise.
10. Enumerate the major aspects that are required to be focused for increasing profitability in a nursery enterprise.

## 10.6 Do It Yourself

1. Visit a Horticultural Nursery and enlist the various components of capital investment.
2. Visit a vegetable seedling production nursery and record the types of vegetable seedlings grown in the nursery.
3. Visit a fruit crop nursery and discuss with the nursery owner about the government subsidy schemes for nursery and record your observations.

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