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Chapter 6

Fruit and Vegetable Nurseries: Establishment and Management

Saeed Ahmad, Irfan Ashraf and Muhammad Akbar Anjum♦

Abstract

Fruits and vegetables have very important place in human diet due to their nutritional status. It is well recognized now that the area under fruits and vegetables should be increased. However, the major problem in this regard is non-availability of true to type and healthy nursery plants. Nurserymen are still using traditional methods to raise the nursery plants. The quality and production of fruits and vegetables depends on the nursery plants those are transplanted to establish orchards. Therefore, it is very important that the nursery should be established by adopting advanced technology that can provide healthy, disease-free and true to type plants to the growers. The aim of this chapter is to provide guide lines to nurserymen and growers to raise nursery plants by adopting modern techniques. This chapter provides information regarding modern nursery structures, mother stocks, characteristics of mother stocks, rootstocks, characteristics of ideal rootstocks, selection of media, types and sterilization of media. The most important significant part of this chapter is sexual propagation, types of vegetative propagation, integrated nutrient management, types of organic and inorganic fertilizers for raising nursery plants. Raising of vegetable nursery, types of vegetable nursery, plug culture, insect-pests and diseases management of vegetable nursery are also discussed in detailed in this chapter. The last part is about the significance of registration, certification and marketing of

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nursery plants. We hope this chapter will be quite useful to nurserymen and students as well.

Keywords: Bio-fertilizers, certification, IPM, media, propagation, sterilization, structure, vegetative method.

6.1. Introduction

The productive life of orchards is reducing day by day. Unhealthy nursery plants are one of the major problems. Nursery plants production is one of the key steps in establishment of modern orchards. This step should be planned and implemented properly by adopting the scientific techniques. These nursery plants contribute to their survival rate after planting and subsequent growth performance. Good quality nursery plants have positive correlation with their survival, growth and productivity. Different types of nurseries are available where no phyto-sanitary measures and disinfection of tools are practiced. No treatment against soil borne diseases and nematodes is done. These nurseries spread diseases (viruses etc.) and hence affect productive life span of orchards.

The success of fruit orchards and vegetable farms depends on the reliable planting material. Diseased and genetically inferior plants have catastrophic effects on the productivity of fruit industry. Basically, all plants multiply themselves by sexual propagation (seed) or by asexual propagation (vegetative) methods. However, researcher /propagators have developed some other techniques for the rapid and better multiplication of plants.

To increase the life span of fruit trees, production of good quality fruits and to establish successful nursery business, it is very important that nursery should be established on scientific lines. The selection of nursery site, nursery structures, media and their sterilization, mother stock and rootstocks are major factors those should be considered carefully to produce good quality nursery plants. True to type plants can be raised only by vegetative means of propagation. Many new techniques of vegetative propagation have been developed with the progress of time. New dimensions of plant propagation are being introduced worldwide by plant propagators to increase the efficiency of the methods as well as the quality of the plants. Nursery plants need to be protected from extremes of environmental conditions until they are strong enough to withstand them. Green houses, mist propagation units, seed production technology, use of growth regulators, container growing techniques, pre-sowing treatments of seeds, hybrid seed of vegetables and plug culture in vegetables are new techniques being used for multiplication of horticultural plants.

6.2. Establishment of Modern Fruit Plant Nursery

A nursery is a place, where different type of plants are propagated and grown to usable sizes. A comprehensive definition of nursery is “the place, where seedlings, saplings, trees, shrubs and other plant materials are grown and maintained until they are shifted to a permanent place”.

6.2.1. Modern Nursery Structures

Young plants and newly emerged seedlings need special care for nutrition, protection against adverse weather, insect-pests and diseases. Therefore, a nursery should have advanced structures to facilitate seeds to germinate, initiate roots and to protect the seedlings against adverse climate and diseases (Awasthi et al. 2006). A modern nursery can have the following structures:

Greenhouse

Greenhouse is a structure covered with transparent material and with controlled environment inside for growing and maintaining plants. Greenhouses have several types depending upon their shape and orientation. History of greenhouses indicates that their use was started in 1599 in France (Khan et al. 2005). The structure of greenhouses was modified by the scientists to improve its efficiency according to need of the time. A greenhouse framework can be established with wooden poles, tubular steel, aluminum or flats frames, polyvinyl chloride (PVC) piping, fiberglass, acrylic and polycarbonate panels as well as pressure heated wood. Poles and frames are covered with fiber glass or glass panels. Temperature is maintained inside the greenhouse in summer by using exhaust fans at one end and cooling pads at the opposite end. The night and day temperature is fixed according to the requirements. Greenhouse contains benches or beds and drip or sprinkler irrigation system is installed for the irrigation of plants.

Greenhouse style, greenhouse covering, greenhouse frames, operating systems and accessories are basic elements those are considered before their construction (Boodley 1998). Following structures are mostly used in greenhouses:

Polytunnel

In this type, polyethylene is used to covers raised beds. Sticks of bamboo or poles of other material are used to support the polyethylene over raised beds and this is called as polytunnel. Temperature increases inside the tunnel and protects the plants against frost. It also conserves moisture. Polytunnel is more effective than thatch roof (Rahudkar et al. 2010).

Glasshouse

Steel, aluminum or wooden frames are used to construct this type of house and top is fitted with plastic, fiberglass or glass. These structures must have adequate ventilation to control temperature. Nursery is raised inside the house on beds or in pots arranged on benches (Boodley 1998).

Poly-house

A poly-house is a polyethylene tunnel which can be made in different shapes and is widely used to produce off-season seedlings and also to protect the seedlings against adverse weather conditions. In modern poly-houses, thermostat, hygrometer, good ventilation system, drip irrigation and fertigation system are maintained to provide required inputs to the plants (Boodley 1998).

Net house

It is like poly-house except that it is covered by a net and is used to protect plants from environmental factors especially high temperature and solar radiation during summer. Size of net house depends on the requirement of growers and its roof is mostly covered by gunny bags, green cloths or any cheaper material that can cut off the solar radiation and keep the house cool (Acquaah 2009).

Plastic tunnel

Plastic tunnel is a simple, cheap and most effective structure to protect the young plants. One-meter-wide loops which support the polyethylene are made from 0.5 cm diameter wire and are erected at 0.75 m intervals. A white translucent polyethylene sheet of 2 m width is then stretched over the loops and is fastened to the frame of the tunnel. Plastic tunnels are quite effective for seed germination as well as rooting of cuttings during winter season (Hartmann et al. 1996).

Mist chamber

Mist propagation chamber is a unit where artificial relative humidity is maintained more than 90% by spraying water with pressure. It is most effective for root initiation especially in soft wood cuttings. This method protects the cuttings against fungal infection by washing the spores. Special nozzles those can produce very fine mist are used in this technique. The chamber can be placed in a poly-house or greenhouse (Kleyn et al. 2013).

Hot beds

For root induction, optimum germination, healthy and vigorous growth of seedlings hot beds are used in nurseries. These hot beds composed of large box along with slanting glass lid. The size of bed is 1-2 meters. The side walls are made of concrete or decay resistant wood. Heating is provided from the base through various means. Heating wires are spread in the base of bed and thermostat is installed to control the temperature. A layer of germination medium of 20-30 cm thick is spread on these wires (Khan et al. 2005).

Cold frames

Cold frames are made by putting plastic glass or cloth cover and masonry walls on the sides. Cold frames are necessary to protect plants from light, frost, heavy winds and rains. The beds are filled first with bricks and crocks followed by sand (Khan et al. 2005).

Lath house

A lath house is a valuable asset for raising seedlings, rooted cuttings, and young plants prior to setting them out in the garden. Lath house modifies the environment by reducing the intensity of sunlight in summer. It provides protection to the plants against high temperature and hot, drying summer winds. During winter, sides may be covered by plastic sheeting, which will furnish additional protection from the winter cold (Acquaah 2009).

Containers

Large number of containers other than clay pots is used in nurseries. These containers are used for raising fruit plants and are made of PVC, plastic, peat, fiber, paraffin paper and polyethylene (Fig. 6.1). These are also used in houses or indoor for aesthetic purposes.

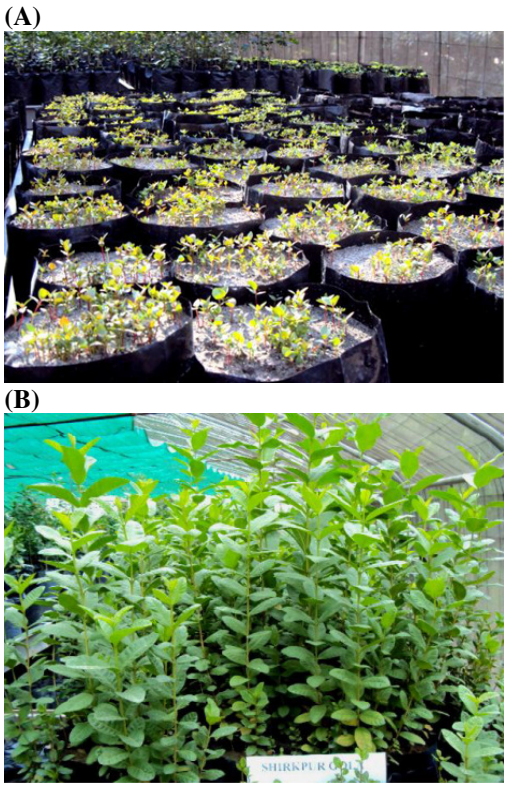

Fig. 6.1 Guava seedling grown in polyethylene bags (A) and plants ready for transplanting in the field (B).

6.2.2. Establishment and Care of Mother Stocks

Success of a nursery depends on genetical purity of mother plants. It is because the mother plants are main source of buds for budding and grafting. Therefore, a separate block is allotted for planting of desired varieties. Mother plants are selected based on good characteristics and are planted at recommended distances. Management practices such as control of pests, diseases, weeds, balanced nutrition and irrigation are performed regularly for good and healthy vegetative growth.

Characteristics of a good mother plant

- The mother plant must be true to type (genetically pure) and superior in quality.
- It should be vigorous, healthy, high yielding and regular bearer.
- It should be free from insect-pests, diseases and viruses.

- It should either be raised in the nursery or obtained from a reliable nursery according to the demand of people and receipt should be preserved to show the originality and authenticity of stock.

Care of mother plants

- Use good quality water to irrigate mother plants.
- Apply manure and fertilizers at proper stage in proper quantity.
- Vegetative growth is encouraged to for maximum number of bud sticks.
- Maintain health of mother plants by regular testing of for control of viruses and other organisms.
- Record is kept about parents, pedigree and bearing habit of mother plants.

6.2.3. Establishment and Care of Rootstocks

In modern fruit culture, due to established effects of rootstocks on scion cultivars, rootstocks have now become the integral part of fruit industry. Rootstock cannot be changed during the life time of a plant; therefore, it is very important to give due attention at the time of its selection. Rootstock influences production, vigour, leaf nutrients status, fruit characters (fruit weight, rind/peel thickness, seed number etc.), and precocity in bearing, fruit maturity, fruit quality and resistance against diseases, insects and adverse climates of scion. Hence, rootstock should be selected properly and planted carefully (Copeland 1976). Mature disease-free seeds of desired rootstocks are collected and sown on well prepared seed beds. Proper irrigation, nutrition, weed management, insects and diseases control practices are performed regularly and properly to raise healthy rootstocks (Rahudkar et al. 2010).

Characteristics of an ideal rootstock

- It should be easy to propagate and must have healthy root system to uptake nutrients and provide good support to hold the composite plant in soil.
- It must produce good, clean, upright stem which can be easily budded or grafted.
- It should have good adaptability to soil and climatic conditions.
- It must have good resistance against diseases and insect-pests, and tolerance against adverse climatic conditions.

6.2.4. Selection of Media

The substrate on which seeds are sown, germinated, seedlings grown and cuttings rooted is known as growing medium. Different ingredients are used in varying composition for preparing commercial or homemade growing media. Media for plant growth and seed germination have 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 natural or manufactured artificially (Stefferud 1961).

Nurserymen use different types of media for different plant species (Khan et al. 2005). However, ideal medium has the following qualities:

- Should be firm and dense that can hold the propagation material (seeds, cuttings, layers etc.) properly.
- Should have good water holding capacity and must be porous so that air can move and excessive moisture can drain out easily.
- Should be free from weeds, diseases and insect-pests.
- Should be properly decomposed with pH range from 5.5-6.5, C: N 20:1 and very low concentrations of salts.
- Should be cheap, easily available and can easily be mixed with other media.

Types of media

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 (Acquaah 2009). The media which are commonly used with a brief description of properties are given below.

Garden soils

Garden soils are usually rich in nutrients and have good water holding capacity. However, these are not suitable for containers because weed seeds and diseases can be a problem. These soils are heavy and have an advantage of anchoring plants in pots, but the disadvantage is difficulty of moving/shifting the pots from one place to other (Acquaah 2009).

Soil mix

Soils are mixed with sand, silt, compost and well rotten farm yard manure (FYM) or some other synthetic media in different proportions. The porous mixture with good water holding capacity is considered good for these purposes (Usman et al. 2013).

Commercial soilless mixes

These are considered as the best choice for containers. These are light in weight, well drained with excellent nutrients and water holding capacity. These are also weeds, insect-pests and diseases free and having a pH of almost 6. These are comprised of sphagnum, peat moss, perlite, vermiculite and little amounts of fertilizers or lime *e.g.* Reddi Earth™, ProMix™, Sunshine Mix™, and Jiffy Mix™.

Other types of commercial mixes

These may be known as planting mix, planting soil, potting soil, or top soil. These vary in their composition and nutritional status.

Sand

Quartz sand is mostly used as a propagation medium by mixing it with different organic matters. It is recommended that sand should be washed, fumigated or heat-treated to kill the pathogens before use (Khan et al. 2005).

Vermiculite

It is a hydrated magnesium-aluminum iron silicate which contains good quantity of nutrients for plants. Vermiculate is mostly used in developed countries as a propagating medium. It is light in weight, neutral in reaction, insoluble in water and has a good water holding capacity. It has ability to hold the nutrients for long period and release them later due to high cation exchange capacity (Khan et al. 2005).

Peat

Peat is partially decomposed parts of aquatic, marsh or bog plants. Composition of different peat deposits varies depending on the types of plant material.

Perlite

It is gray-white silicaceous material of volcanic origin, which is mined from lava flows. Perlite is prepared by crushing crude silicaceous material and heating at 760ºC It has pH of 6-8, high cation exchange capacity and good water holding capacity with no buffering capacity. It is mostly used in combination with other propagation media because it contains no minerals. However, it can increase aeration in the mixtures (Rahudkar et al. 2010).

Leaf mold

Decomposed plant leaves are called as leaf mold. Some chemical fertilizers especially urea is also added to decompose the leaves. Composition and colour of leaf mold is original material dependent. Treatment of leaf mold with fungicide and insecticides is considered good to make it free from insects, their eggs and pathogens. Nutritionally it is good because it contains all the essential plant nutrients (Khan et al. 2005).

Compost

Decomposed organic wastage is called as compost. It is a rich source of mineral nutrients and has a good water holding capacity. It can be mixed with soil to use as a medium for propagation. Preparation of compost is divided into three main steps; decomposition of degraded material, decomposition of cellulose compounds at higher temperature and decolonization of microorganism. Pasteurization of compost before use is very important to make it free from different pathogens.

Sawdust and wood shavings

These are mostly used for propagation media. Different controlled release fertilizers are used along with sawdust to increase the nutritional status.

Coco peat

It is also called as coco dust. It is considered the most popular growing medium available these days due to fine structure having excellent aeration of 15-25%. 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 need to break down easily degradable substrates present in coco peat.

6.2.5. Sterilization of Media

Many nursery growers sterilize soils and other mixes before use. Sterilization is a costly and labour intensive technique. Sterilization usually controls the nematodes, soil-borne pathogens and many weeds. Various liquid, granular and gaseous compounds are being used for soil sterilization. Proper sterilization depends on various factors including soil temperature, soil moisture, soil cover and plant residues (crop debris, weeds etc.) present (Rahudkar et al. 2010).

Most of the nursery problems are associated with contaminated media used for plant propagation. Pathogenic and weed problems can successfully be minimized by regular use of clean and sterilized media. Several methods can be used to sterilize the media.

Soil solarization

In solarization, the media is kept at 60-70°C for 60-75 min. Fumigation is accomplished by mixing the media with formaldehyde (2% solution) or methyl bromide 0.5 kg per square meter under plastic sheet or in a gas-tight chamber for 24 h. It is also very important that soil temperature must be 16°C or above. However, some scientists do not recommend the fumigation due to the harmful effects of methyl bromide on human health. Most of the scientists are agreed that media sterilization through solar energy and steam are better and safe technologies. Among solar and steam sterilization, later is considered better technique for producing clean and healthy nursery plants. Steaming the soil media does not has any drastic effects on nutritional status and physico-chemical characteristics including pH, organic matter, EC and water holding capacity of media (Rahudkar et al. 2010).

- May-June is the most suitable time as intensity of solar radiation is highest in these months and temperature may rise up to 45ºC.
- During this process soil is also kept mosit with water.
- Cover it a polythene sheet for 4-6 weeks in this way that air could not enter. This will increase the inside temperature very high and all soil borne pathogens will be killed. After removal ofpolyethylene media is used to prepare beds for seed sowing.

Formalin solution treatment

The treatment is usually done 15-20 days before seed sowing. Soil is drenched with Formalin solution (2%) @ 4-5 L per square meter to saturate the soil up to 15-20 cm depth. Soil is then covered with 200-gauge polythene sheet and margins are sealed with wet soil to keep it air-tight. After 15 days, polythene sheet is removed and beds are prepared for seed sowing.

Application of fungicides

Commonly, fungicides like Captan, Benomyl, Confidor, Antracol etc. are used for harmful soil borne pathogens. Fungicides are applied @ 6-7 g per square meter of nursery and thoroughly mixed in the soil.

Application of insecticides

Eggs and larvae of many insect-pests are present in the nursery soil, which cause damage to seedlings. Insecticides can be used to kill these insect-pests and their eggs. Chloropyriphos @ 3 mL per liter of water is applied up to a soil depth of 15-20 cm to control the insect-pests in soil.

Steam treatment

Harmful insect-pests and their eggs can also be destroyed by using hot steam. Stop the aeration in the covered area with the help of polythene sheet and apply hot steam continuously for 3-5 h. Harmful pathogens will also be killed by this method.

6.2.6. Selection of Containers

In modern nurseries, plants are grown in containers, made of polyvinyl chloride, plastic, metal or clay. However, peat fiber pots, paraffin paper cups and polyethylene bags are also common (Hannah 2002). Advantages of container grown nurseries include:

- More efficient use of resources *i.e.* space, water and fertilizers.
- Management of nursery is easy and with less labour, more plants can be raised in same space.
- Due to shallow tap root system, transportation and transplanting of plants are easy and without any root damage. Moreover, plants can be raised and transplanted whole the year round.
- Plants can be shifted/ stored under shade before planting without any mortality issues.
- Nursery production in containers has gone through many changes in the last few years. In past, mostly peat-based containers were used for growing nursery plants. Now-a-days, nursery growers mostly raise nursery in hardened polystyrene or plastic containers. Clay pots, peat containers, plastic pots, peat pellets and fiber blocks are not commonly used for mass production of nursery plants. Although use of polystyrene and plastic containers is a significant financial investment; however, most of these can be reused several times. Reusable containers must be sterilized after every use. Usually 10% chlorine bleach solution is used for sterilizing the containers. Plastic containers do not have small pores and crevices unlike polystyrene containers that may cause disease problem. Plastic containers are difficult to clean because they have many edges, and also provides proper environment to pathogens. Plastic containers contain two parts; a flat with reusable plastic tray of several sizes and configurations. Commonly inserts are used only one time.
- Various types (sizes, shapes and configurations) of containers are available in market. Choose the type which is best for the selected system. Polystyrene and plastic containers are mostly arranged in straight rows in nursery. Polystyrene containers commonly have inverted pyramid type cells that narrow toward the base. Cells are mostly small in size as 2 cm square

or as large as 20 cm square. The number of cells in a container depends on cell size. There are 16 to 400 cells per container.

- Most recently, plastic flats with single piece have become common for nursery production. These are larger than standard flats (25-50 cm). These are more rigid than the inserts and are used with standard flats. These flats can be reused like polystyrene containers but are more resilient and easier to clean. Plastic and polystyrene inserts are available in a variety of sizes. There are a number of disadvantages of polystyrene or plastic trays other than sanitation problems as these are not biodegradable. Sometimes it is difficult to remove plants from these, especially if roots are grown through bottom of the tray. However, seedlings can be removed easily if these are wetted prior to transplanting in field.

The following containers are commonly used for growing and propagating plants in nursery.

Flats

These are shallow earthen, reed, Polyvinyl chloride (PVC), Reinforced Cement Concrete (RCC) metal or plastic trays, having drainage holes at bottom (Hannah 2002). Size can vary according to the purpose or type of nursery plants. These can be resued many times.

Clay pots

Different sizes and shapes are available in the market. Round types occupy more area in nursery and are avoided. These are porous in nature and permit aeration and water movement. However, their continuous use may result in blockage of pores due to accumulation of salts (Hannah 2002).

Plastic pots

Plastic pots are available in square and round shapes and in different sizes. These are non-porous but have several advantages; these are durable, light weight, reusable and require small place in nursery (Rahudkar et al. 2010).

Polythene bags

These are now widely used mainly because these are comparatively cheaper, light in weight and easily available. These are available in different sizes and thickness, and in white or black colour. Polythene bags of usually 10×6 cm size are used for raising vegetable seedlings (Rahudkar et al. 2010).

Others

Besides these containers, peat pots, fiber pots, fiber blocks, root trainers etc. are also used in nurseries for raising seelings.

6.2.7. Propagation Methods

Plant propagation is the process of multiplying or increasing number of plants of specie(s) to preserve or maintain its population. Successful plant propagation

requires practice as well as patience (Ahmed 1994). It is a mean to produce new plants or increase existing plant populations. Domestication and improvement of horticultural crops also depends on their multiplication otherwise these become extinct (Bryant 1995). In fact, nature has enabled plants to multiply themselves by sexual and asexual means. However, for speedy and efficient multiplication, some techniques have been developed by horticulturists (Khan et al. 2005).

6.2.7.1. Sexual propagation

Sexual propagation in plants involves seeds or spores and takes advantage of meiosis and recombination of genetic material. In this case, resulting offspring contains genetic material from both male and female parents. Sexual propagation starts when compatible pollen is sprayed/ dropped on the flower's stigma, which fertilizes the egg in the ovary by growing down through style of the carpel. The embryo formed by the union of pollen and an egg develops into a seed which is often contained in a fruit or similar structure (Kleyn et al. 2013).

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 (Copeland 1976). When it's mature and placed in a favourable environment, it starts its active growth that is called as germination. Seeds are collected from mature and ripe fruits. To obtain high-quality plants through sexual propagation, the following points should be considered for the selection/purchase of seeds (Stefferud 1961).

- Selection of high-quality seed from a reliable source.
- Seed lot should not contain any debris or other crop or weed seeds.
- Select varieties/cultivars with desired size, colour and growth habit.
- Choose varieties/cultivars that are adapted to the prevailing environmental conditions of the area.

Hybrid varieties/cultivars of vegetables and flowers cost a little more than open-pollinated types. However, these are usually more vigorous and uniform, and better in production than non-hybrids. Sometimes they have specific disease resistance or other unique cultural characteristics. The plant produced from a seed is called as seedling. Seed propagation permits production of a large number of plants with ease. This method of propagation has few advantages and disadvantages (Hartmann et al. 1996), as given below.

Advantages

- Production of a large number of plants without much technical expertise.
- Cheaper as well as quicker than other methods.
- In certain species, it is the only viable method of propagation (*e.g.* papaya, falsa, mangosteen).
- Rootstocks are mostly reproduced through seeds.
- Nucellar seedlings can be obtained through this method.
- Seedlings are considered long lived and resistant/tolerant against some diseases and adverse climatic conditions.

- Maintains genetic diversity of plants.
- It may be the only approach to obtain new varieties through breeding and chance seedlings.
- It avoids transmission of diseases, except seed borne ones.
- Seeds are easy to move from one place to other and can be stored for a long period.

Disadvantages

- All plants do not produce viable seeds and cannot be propagated through this method.
- Plants produced are not true to type.
- Seedlings are not uniform in their growth, fruit quality and yield.
- Seedlings have long vegetative phase; therefore, take longer duration to come into bearing.
- Plants reproduced by sexual propagation become tall and their management becomes difficult.
- Seeds after extraction loose viability very soon and thus show low germination rate.

Seed collection

Seeds may be collected from field or bought from a market. However, the selection may be useful if somebody choose to collect seeds himself. Seeds are usually developed within a fruit. Selection and collection of good seeds before sowing are directly related to the success of nursery business (Acquaah 2009). Therefore, the following points should be considered during the selection and collection of seeds:

- Select healthy and vigorous plants with desirable characters, *i.e.* plant shape, size, and fruit yield and quality etc.
- It is preferred to collect seeds from several plants in a particular area.
- Select mature, ripe, uniform and healthy fruits for seed extraction.
- Seeds should be extracted safely using proper method.
- Make the seeds free from pulp/juice by washing or cleaning.
- Select undamaged, healthy and viable seeds.
- Label the seeds when collected or describe the plant for later identification.

Transportation

Freshly collected fruits or seeds are transported in calico bags or open trays to allow good ventilation. Green fruits or damp seeds must be well ventilated. Moist storage conditions may encourage development of diseases, germination and spoilage of seeds (Dirr and Heuser 1987).

Seed storage requirements

Most flower and vegetable seeds can remain viable for more than one year, but germination percentage will decrease with age. Seed storage, its viability and germination percentage are usually determined by the type of seed and the storage conditions (for details, see section 5.5). Proper storage conditions such as cool, dry and dark environment with 3-12°C temperature and 25-35% relative humidity are considered the best for storage of seeds (Stefferud 1961).

Pre-sowing seed treatments/ methods to break seed dormancy

Some seeds have germination barriers/inhibitors that prevent them from germinating even when sown under favourable environmental conditions. This condition is called as seed dormancy. It might be imposed by hard seed coat, impermeability to water and gases, presence of inhibitors or immature embryo (Ahmed 1994). These seeds require specific treatments before sowing for their germination. In some cases, seed dormancy is difficult to break, even under favourable and ideal environments (Dirr and Heuser 1987). Various treatments are applied to the seeds to break their dormancy and enhance germination which are described below.

Seed scarification

Seed scarification involves breaking, scratching or softening the seed coat to make it permeable to water and gases for initiating and accelerating 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 for 10 min to several hours depending on hardness of seed coats, and concentration of acid. When seed coat becomes thin, the seeds can be removed, washed and planted.
- Mechanical scarification is another method in which seeds are scratched with a metal foil, rubbed with sandpaper or cracked with a hammer to weaken the seed coat.
- Hot water scarification involves immersing the seeds in hot water (77 to 100°C). The seeds are soaked in the water, allowed to cool for 12 to 24 h and then dried in shade before planting.
- The fourth method is warm, moist scarification. In this case, seeds are stored in non-sterile, warm, damp containers where the seed coat will be broken down by decay over several months.

Seed stratification

Seeds of some fall-ripening trees and shrubs of temperate zone fail to germinate unless chilled underground as they overwinter. This is so called “after-ripening” and may be accomplished artificially by a practice called stratification (Copeland 1976). The following procedure is usually successful.

- Put damp sand or vermiculite in a clay pot to about 2.5 cm from the top.
- Remove any fleshy outer coating present over the seeds.

- Place the seeds on top of the medium and cover with 1.25 cm of damp sand or vermiculite.
- Place the pot containing the moist medium and seeds in a plastic bag, seal it and place in a refrigerator.
- Medium should be moist but not wet.
- Remove the bag after 10 to 12 weeks and set the pot in a warm place indoor. Soon the seedlings will emerge. Transplant the young plants into pots as they attain a height of 7 to 8 cm.

Another procedure that is usually successful uses sphagnum moss or peat moss.

- Wet the moss thoroughly and squeeze out excessive water.
- Mix seeds with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator.
- Check periodically and after 10 to 12 weeks remove the bag from refrigerator.
- Plant the seeds in pots to germinate and grow.

Small roots and shoots often emerge at the end of stratification period. Care must be taken not to break these off. Temperature in the range of 2 to 7°C is quite effective. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of plums, apricots, peaches and nectarines should be removed from the hard pits. Care must be taken when cracking the pits, because any injury to the seed itself can be an entry path for disease organisms. Seeds of different fruits need different temperatures and durations for breaking their dormancy (Table. 6.1).

Table 6.1 Stratification requirements of various temperate fruits to break dormancy.

Fruit	Chilling temperature (°C)	Duration (Days)
Plum	Below 7.2	37-70
Apple	Below 7.2	10-70
Raspberry	Below 7.2	33-70
Walnut	Below 7.2	16-62
Peaches	Below 7.2	33-70
Sour cherry	Below 7.2	25-58
Sweet cherry	Below 7.2	20-54
Almond	Below 7.2	4-16
Grapes	Below 7.2	4-62

Leaching

Presence of chemical inhibitors in some seeds may also prevent or delay germination and it is possible to remove these chemicals by leaching with various solutions. It has been reported that suspending the seeds of *Eriostemon* and some *Correa* species in a muslin bag in running water for 1-2 weeks, significantly improves germination but it is not applicable for home gardeners. Leaching solutions that have been used include alkaline solutions. Alternately, seeds may be treated with plant growth

regulators like GA_3 to make a balance between growth inhibiting and growth promoting substances (Stefferud 1961).

Seeds can be sown in pots, trays, plastic bags or in beds in the soil in lines. Some seeds are directly sown in the field at proper plant to plant and line to line distance or directly can be sown in polyethylene bags (Fig. 6.2). The seedlings are budded or grafted on the same place. In nursery, seeds are sown in well prepared beds at line to line distance of 10 cm. The sowing depth of seeds depends on the seed size. Good results can be achieved if seeds are covered with a suitable medium to thickness of two to three times of its diameter. Light irrigation is applied after sowing. Over irrigation or standing water is harmful for seeds.

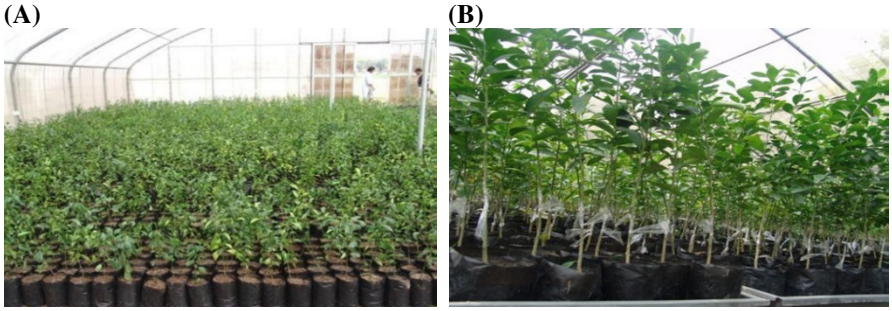

Fig. 6.2 Citrus seedlings are raised (A) and budded (B) directly in polyethylene bags.

6.2.7.2. Asexual propagation

Asexual propagation is carried out by using vegetative parts of plants (roots, stems or leaves) to regenerate new plants. It involves only mitosis, which is non-reductive cell division and no genetic recombination occurs in this type of reproduction. Offsprings are genetically identical to the mother plants and have the following advantages as compared to sexually produced plants (Khan et al. 2005). Brief information about plants propagation methods are given in Table 6.2.

Advantages

- The plants reproduced by asexual propagation are true to type, uniform in growth, fruit yield and quality.
- Faster than sexual propagation, large plants can be obtained within short time.
- Asexual propagation produces dwarf plants; therefore, management practices are easier, less costly and more number of plants per unit area can be transplanted, as compared to seedlings.
- The plants have shorter juvenile period; therefore, they come into bearing earlier as compared to seedlings.
- Early assessment of hybrids is possible by budding or grafting them on already grown plants and established trees.

- The benefits of rootstock can be achieved such as resistance against diseases and abiotic stresses.
- It is the only way to perpetuate some cultivars those produce seedless fruits such as banana, pineapple, fig and some varieties of grapes.
- Inferior varieties/cultivars can be replaced by adopting the top working method.
- Damaged parts of the plants can be repaired by using suitable methods of grafting, *i.e.* bridge grafting.

Disadvantages

- Plants are short-lived and sometime this method is expensive and needs special expertise.
- New varieties/hybrids cannot be evolved by this method.
- Plants are usually more susceptible to insect-pests and diseases.

Table 6.2 Different methods of vegetative propagation in various horticultural crops.

Propagation Methods	Types	Examples
Cuttings	Hardwood cutting	Fig, grape, quince, pomegranate, rose
	Semi-hardwood cutting	Lemon, mango, jackfruit
	Softwood cutting	Apple, peach, plum, apricot and cherry, guava
	Root cutting	Apple, pear, cherry, guava
Grafting	Whip grafting	Walnut, apple, pear
	Cleft grafting	Grapes, avocado, apple, pear, plum, camellia
	Bark grafting	Different temperate fruit plants
	Side grafting	Mango, avocado, ber
	Approach grafting	Mango, guava, litchi
	Veneer grafting	Mango
	Bridge grafting	This is not propagation method but used for repairing of the damaged fruit plants
Budding	T- budding	Citrus, plum, peaches, cherry, ber
	Patch budding	Walnut, pecan nut
	Chip budding	Grapes
	Ring budding	Peach, plum, ber, mulberry
Layering	Tip layering	Black berry, black raspberry
	Simple layering	Gapes, lemon
	Mound or stool layering	Apple rootstock, gooseberry
	Air layering	Litchi
Runners		Strawberry, spider plant
Suckers		Dates, banana
Separation	Bulbs	Ornamental plants
	Corms	Ornamental plants
Division	Root tubers	Sweet potato
	Stem tubers	Potato
	Rhizomes	Banana, ginger, turmeric

Types of vegetative propagation

Grafting and budding

Grafting and budding are the techniques of vegetative propagation that are used to combine parts of two different plants to encourage growth as a unified plant (Fig. 6.2). In this technique, single bud or a piece of shoot containing several buds (scion) of a desired plant is attached to a rootstock plant. Usually, grafted and budded plants can be divided into two parts, scion and rootstock. Scion is top of the plant, while rootstock is the lower portion (root system) of composite plant (Khan et al. 2005).

Bud wood is used as soon as possible after its collection. However, it can be stored for 2-3 months under proper conditions (Sharma and Serivastav 2004). Bud sticks are placed in sealed polyethylene bags and stored at 4-7°C. The vegetable drawer of the refrigerator is usually ideal for bud wood storage. Water or wet packing material in the storage bag can cause the bud wood to mold or decay. Bud wood should be inspected every 2 to 3 weeks for the presence of mold, or excessive moisture inside the bag. Affected bud wood should be washed and returned to storage in a clean bag. Lightly molded bud wood should be carefully washed in cold, mild soapy water, rinsed and stored in a clean bag. Bud wood which is excessively moist should be lightly blotted with paper towels. Shriveled, darkened, or bud wood heavily infected with molded should be discarded. Stored bud wood should be kept moist and cool, but not wet. Remove budwood from storage just a couple of hours before its use (Dirr and Heuser 1987).

Before attempting budding or grafting procedures, the following items should be on hand and in good working conditions. A razor-sharp knife is needed to make smooth, clean cuts necessary for sufficient contact between scion wood and rootstock during the healing process. Knives specifically designed for budding or grafting are available at garden supply stores and are usually better, although some pocket knives are also suitable. The blade becomes dull with use and require periodic sharpening or replacement. Pruning scissor is needed for preparation of graft wood or scion. Polyethylene budding tape (available in clear or green) is used to wrap matrix to prevent drying and promote graft/bud union formation. Clear tape permits observation of the union during healing process. Now, very sophisticated budding materials are available in market that should be managed according to the requirements (Hartmann et al. 1996).

Cutting

It can be defined as the propagation of plants by the detachment of plant parts, which have the ability to produce roots and shoots under favourable conditions and develop into complete plants identical to the parent from whom these were taken. This method is quick and cheap but it is practicable in plants those have ability to produce roots easily. Grapes, fig, pomegranate, plum, pear and sweet lime can be successfully propagated by this method (Kleyn et al. 2013). The lower portions of cuttings are treated with different rooting hormones with different concentrations for getting maximum success (Table 6.3)

Table 6.3 Hormones used for rooting in hardwood cuttings of some fruit plants.

Sr. No.	Fruit crops	Concentration of hormones	Time of treatments
1	Grapes	100-200 mg L^{-1} IAA	24 hours
2	Sweet lime	Powder Seradix A	Touch methods
3	Pear	50-100 mg L^{-1} IBA	24 hours
4	Guava	50-100 mg L^{-1} IAA	24 hours

Layering

Some plant species cannot be propagated by cuttings because they do not readily form roots. However, in these plants, roots can be induced on shoots before these are detached from mother plants. Shoots while attached to their parent plants may form roots at the point touching the rooting medium. The rooted shoot becomes a new plant when removed from the parent plant. This method of propagation is called as layering or layerage. It has a high success rate because it prevents water stress and carbohydrate shortage that may cause death of the cuttings. Some plants layer themselves naturally but sometimes plant propagators assist the process. Layering is enhanced by girdling the stem where it is bent, by wounding it on one side or by bending it very sharply and then covering with rooting medium (Kleyn et al. 2013). The rooting medium should provide aeration and a constant moisture supply. Different layering methods are uused for vaious fruit crops (Table 6.2).

Runners

A runner is a specialized stem which develops from the leaf axil at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes. The strawberry is a typical plant propagates in this way. In most strawberry cultivars, runner formation is related to day length and temperature. Runners are produced in long days of 12 to 14 h or more with high mid-summer temperatures. New plants are produced at alternate nodes, stems die in the late fall and winter and each daughter plant separates from the others (Hartmann et al. 1996).

Suckers

A sucker is a shoot which arise on plant from below ground level. The most precise use of this term is to designate a shoot which arise from adventitious buds on a root. The tendency to produce suckers is a characteristic possessed by some plants. Suckers are dug out and cut from parent plant. In some cases, part of the old root may be retained, although new roots arise from the base of sucker. They are usually dug during dormant season (Kleyn et al. 2013). Date palm and banana plants are asexually propagated by this method. The success of sucker depends on its age, planting season and method of transplanting.

Plant tissue culture

Use of tissue culture is increasing for mass propagation of fruit plants. Detail of tissue culture techniques can be seen in chapter 4 section 4.2.

6.2.8. Irrigation Practices in Nurseries

The nursery plants are very sensitive to salts; therefore, it is very important that before making decision to establish a fruit plants nursery, the quality of irrigation water should be examined. All types of irrigation water contain different soluble salts such as calcium, sodium, magnesium and others. Excess amount of any component in water can degrade the quality of water and develop toxicity. The analysis of irrigation water should be carried out by Government Lab, especially when underground water is used (Christopher 1992).

Optimum irrigation is required to maintain the adequate soil moisture for both field and container grown nurseries. Irrigation of nursery plants depends on the weather but over irrigation and drought both are harmful for plants. Most of the commercial nurseries use overhead sprinkler or drip irrigation system. In this system, equal distribution of water and fertilizers is possible which is very important for healthy plants (Schroeder et al. 1997).

6.2.9. Integrated Nutrient Management

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 their interactions in soils, interaction between their availability in root zone and during growing season in relation to their demand by crop (Sharma and Serivastav 2004).

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 (Schroeder et al. 1997). The IPNS 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, and 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.

These can be grouped in to three groups such as organic manures**,** inorganic fertilizers and bio-fertilizers.

Organic Manures

Bulk organic manures have been major traditional means of sustaining plant nutrients in soils throughout history and equally as important as today (Christopher 1992).

Green manure

It refers to incorporation of green twigs and leaves collected from shrubs and trees grown on ridges, 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%.

Livestock and human waste

It includes cattle and buffalo dung and urine, other livestock and human excreta, byproduct of slotter house and animal carcass such as blood, meat, bones, horns, hooves, leather and hair waste.

Inorganic fertilizers

Cultivars need additional quantities of nutrients due to their high yield potential. Organic manures and biofertilizers are incapable to fulfill the entire nutrients requirement of individual plant. It is very necessary to provide them other nutrient to fulfill the entire nutrient requirement of the plants. Inorganic fertilizers play a vital role in satisfying the nutrient requirement of these plants (Schroeder et al. 1997).

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 (Christopher 1992).

Biofertilizers

Mixtures containing live or latent cells of efficient strains of nitrogen fixing, phosphorus solubalizing or cellulytic microorganisms are called as biofertilizers. Biofertilizers are applied to seed, soil or compost with objective of increasing the number of such microorganisms and accelerate microbial processes to augment the extent of availability of nutrients in a form that can be easily assimilated by plants (Christopher 1992).

6.3. Raising of Vegetable Nursery

Nursery raising is a very important operation in successful production of vegetables (Fig. 6.3). Raising vegetable nursery from seed provides an easy and convenient way to nourish tender young seedlings in a well-managed small and compact area. It is also helpful for better germination of small and costly seeds. A small area can be easily provided with favorable conditions. Some vegetables like sweet potato, potato, turmeric, ginger, taro and cocoyam do not produce seeds under normal conditions and are propagated asexually. Vegetables like carrot, radish, turnip, peas, beans, cucurbits and leafy vegetables are propagated by seeds, which are directly sown in open fields (Arya 2003). While, seeds of some vegetables *i.e.* cauliflower, cabbage, Brussel's sprout, broccoli, lettuce, onion, tomato, chilli, eggplant etc. are first sown in nursery and when seedlings attain a suitable height, these are transplanted in open fields. For raising a good crop, it is essential that seedlings should be healthy, vigorous and disease-free. Following are some advantages of raising nursery are:

- Seedlings are provided with good conditions for growth and development.
- Small and costly vegetable seeds can be used efficiently and judiciously.
- It is easy, convenient and cheaper to manage seedlings, *i.e.* irrigation, weeding, disease and pest control, and protection against inclement weather conditions in a small area.
- Availability of sufficient time for field preparations, manure and fertilizer mixing after harvesting the previous crop, thus crop can be sown at proper time.
- Higher yields in many cases are obtained because some vegetables perform better upon transplanting, as compared to direct seeding.

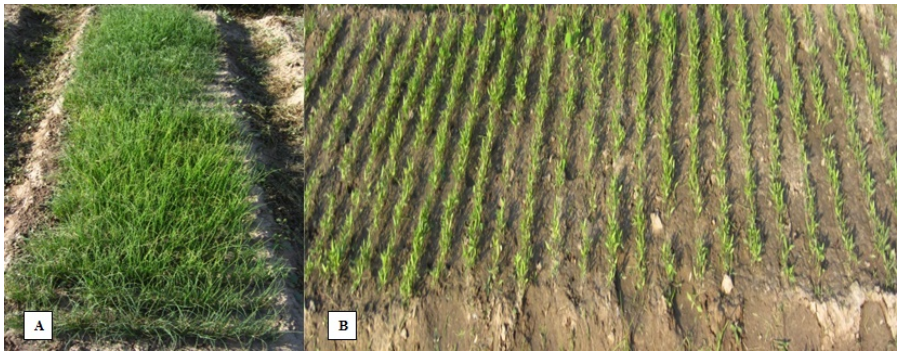

Fig. 6.3 Raising of vegetables nurseries (A) onion and (B) tomato.

6.3.1. Requirements for Raising Vegetable Nursery

Selection of site

Nursery beds should be prepared in an open place. It is advisable not to select site nearer to buildings or trees. Irrigation facilities should be available at the site. Normally, raised area is preferred. All other inputs and facilities needed for nursery should be available at the spot. Selection of soil for raising seedlings is very important. Soil should be loamy or sandy loam. Acidic or saline soils are not suitable for raising nursery. The pH of the soil should be in the range of 6-7.

Soil preparation

The nursery soil should be porous, pulverized and well aerated. Soil preparation can be done with the help of hand implements like spade, *kasola, khurpa* etc. On leveled soil, raised or flat beds can be prepared depending upon the situation. Number of beds depends on kind of crop and area on which the crop is planted (Arya 2003).

In demarked area, soil is drawn from the sides, so that level of beds is raised to 15-20 cm from natural level of the plot. All big clods, stones, plant stumps, weeds etc. are removed. Well rotten farmyard manure or compost or leaf manure is applied at recomemded doses. The top surface of nursery bed is made flat and smooth.

During spring-summer, seedlings are raised in flat beds. Further, in areas where rainfall is not so heavy and field is well leveled and drained, flat beds are preferred. Normally, area is divided into small beds through ridges around each bed (Fig. 6.3).

6.3.2. Types of Vegetable Nursery

Open field

In this type, nursery beds are prepared after final preparation of the soil. There is no need of any kind of structures. These nurseries are raised only when weather conditions are suitable and favourable for establishment of seedlings.

Thatch roof

Beds are prepared after preparation of soil. Thatch roof are constructed over the basins. In this type of nursery beds, seedlings are protected from frost damage and temperature extremities.

Shade house

In this type of nursery beds, plants are raised under artificial cover (shade or partial shade). Frame is constructed of galvanized iron pipe, wooden or angle iron poles and chicks of *sarkanda* are placed over the frame to create shade, it is called as chick house. Now-a-days different types of synthetic nets of green colour with various mesh sizes and shade percentages (50-75%) are available which are used other than reed or *sarkanda* chicks.

Natural conservatory

In this type, shade or partial shade is developed by planting trees like mango, mulberry, jaman, *Sesbania* etc. in rows and nursery is raised under these trees. The technique is cheaper to raise seedlings during summer for planting early winter vegetables (Hannah 2002).

Micro propagation is a sophisticated tissue culture based method of propagating plants within a short possible time and with a limited stock of plant material. Modern commercial nurseries have a tissue culture laboratory to produce disease-free plants or eliminate viruses from stock plants. The plants produced through tissue culture are delicate and therefore are hardened before transferring to open field conditions (Thorpe 1981).

6.3.3. Plug Culture

Plug or cell transplants are seedlings or small vegetatively propagated plants which are raised in individual small cells, called plugs. This technique ensures that a large number of seedlings can be raised in minimum space under optimized and controlled conditions. In the past, horticultural seedlings for transplanting were produced in hot beds or cold frames by individual growers. The aim was to extend the growing season in regular climate. Now-a-day high-quality seedlings of different vegetables have been produced by groups of growers. Plug production has become an important nursery raising technology (Hannah 2002). Plug technology was developed mostly

for flower crops in the world. Now it is also being commercially currently being used for the production of vegetable seedlings.

Following are salient feature of plug culture:

- Generally, single seed is planted in each plug or cell.
- A plug tray may contain 20 to more than 100 cells.
- When seedlings have grown to 2-3 leaf stage, they are transplanted in flats.
- The plug system is used in highly developed countries mainly for leafy vegetables which are harvested at an early stage when they are young and tender.
- Seed germination is enhanced and plug seedlings have a quick growth rate, a shorter cropping phase and a longer storage life.
- The vegetables grown in porous medium in plug trays have superior root and shoot growth than those in field soil, resulting in superior yield.
- Natural damages to tender seedlings at the nursery stage are greatly minimized.
- Reduces transplanting shock, and plant mortality in field is extremely low.
- Overall operating costs are less, as labour cost is less.
- Inputs required, like water, fertilizers etc., are less.
- However, the system is labour intensive and needs to focus on mechanization and automation of system to decrease labour demand.

6.3.4. Propagation Structures

These structures are facilitated with temperature, humidity and light control, so that seeds can easily be germinated or cuttings can be rooted. Such structures are known as cold frame, hot-bed or greenhouse. The latter structure is also used for hardening young tender plants and preparing them for transplanting outdoors (Dirr and Heuser 1987). Various structures used for propagation purpose are mentioned in section 6.2.1.

6.4. Insect-Pest and Disease Management

Many insect-pests and diseases attack on nursery seedlings; therefore, protection from insects-pest and diseases is very important. Various practices are used to decrease the risk of pests and disease attack and produce healthy and strong seedlings, which include:

- Provide proper aeration, ensure nutrients availability and also maintain soil fertility by applying adequate amount of manures and fertilizers.
- Use only healthy seeds and other planting materials.
- Grow varieties/cultivars, resistant to specific disease or pest, available in market.

- Follow crop rotation to prevent soil-borne diseases. This is also helpful in maintaining soil fertility.
- Remove crop debris and weeds as these act as hosts for pests and diseases.
- Monitor the crops regularly so that problems are detected earlier. Hand destruction of pests especially larvae and egg masses is also beneficial (Rai and Yadav 2005).

6.5. Registration, Certification and Marketing

The main reason for low productivity of horticultural crops in the country is unavailability of genuine planting materials to the growers. Most of the diseases invade fruit plants during their early stages of growth especially in nurseries and flourish inside the plants. This results in inferior fruit quality with low market value and reduced productive life of the plants. These diseased nursery plants are also a source of infection for other plants in the nursery as well as in orchards when transplanted. The major cause is the use of infected rootstock and scion wood. The situation necessitates strict enforcement of rules and regulation regarding the registration and certification of nurseries. Nurseries should be frequently inspected by the competent authority to regulate the supply of quality planting materials to the growers (Florida Department of Agriculture 2014).

In Pakistan, registration of nurseries started under the West Pakistan Seeds and Fruit Plants Ordinance, 1965. Later, under the Seed Act 1976, the Federal Government made the rules called as the Pakistan Fruit Plants Certification Rules, 1998. Now registration and certification is regulated under these rules, which compel all public and private nurseries to be registered with the Federal Seed Certification and Registration Department for production of certified nursery plants. Fruit trees are registered as rootstock and scion sources for the purpose of providing seed and propagating materials for certified nursery plants. For registration, these fruit trees are inspected and tested to be true to type and free from viruses, insect-pests and diseases as specified by the Federal Seed Certification and Registration Department. However, there is no fruit plant certification program in the country in true spirit except in the province of Khyber PakhtoonKhawah (KPK) where a proactive program of registration of fruit nurseries and certification of fruit plants specifically of pome and stone fruits has been initiated. The government of KPK province has established three Germplasm Units (GPUs) for certification of tropical, sub-tropical and temperate fruit plants/ propagating materials at Ratta Kulachi (Dera Ismail Khan), Dargai (Swat) and Bafa (Mansehra), respectively. The government of Punjab has also initiated this project on mango, citrus and peaches and has established 4 GPUs, in Khanewal (Mango), Muhammad Nagar, District Pak Pattan (Citrus) and Sodhi Jaywali, District Khushab (Citrus), and Khatwai, District Khushab (Peach), for the provision of true to type and disease-free nursery plants to the orchard growers. Federal Seed Certification and Registration Department, Government of Pakistan is responsible to regular index GPUs for viral infestation, twice a year at active growth periods. Similarly, one GPU for certification of temperate fruits, especially rootstocks, has also been established at Gilgit in the province of Gilgit-

Baltistan (Ministry of National Food Security and Research 2016). There is need that fruit plant certification system should be extended throughout the country for production and distribution of true to type and disease-free fruit plants of improved cultivars. Further, emphasis should be laid on nursery sanitation and certification of procedure of plant production/multiplication. Recently, Agribusiness Support Fund (ASF) under USAID Agribusiness Project has launched a project to provide support on cost sharing basis for establishing 20 insect-free Screen Houses in different horticultural hubs, especially in citrus producing areas of the country. The main aim of this program is to facilitate the availability of true to type disease-free fruit plants grown under the best practices for the horticulture industry of Pakistan.

Marketing of fruit plants, vegetables and flowers seedlings and nursery products is a highly specialized business (Memon 2016). Every nurseryman wants to earn more and more on his investment. Price of the plants and seedlings mostly depends on demand and supply and also reputation of the nursery. Growers usually prefer to buy the plants of their choice from a known and well-reputed nursery. They prefer container grown plants over field grown plants due to low mortality rate upon planting in the field. Moreover, farmers are attracted by reasonable price, proper packaging of planting material, as well as by provision of transport facilities and brochure regarding package of practices. Further, publicity also plays an important role in the sale of nursery products.

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