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| **Tropical Fruit Crops Production and Management handout** |

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# CHAPTER 1. INTRODUCTION

## Definition of Fruits

What is Hoticulture? The word Horticulture in derived from the Latin word Hortus meaning enclosure (garden) and culture - meaning, cultivation. Thus Horticulture mans culture or cultivation of garden crops. Horticulture may be broadly defined as the Science and art of growing fruits, vegetables and flowers and crops like spices condiments and other plantation crops.

What are the basic division of Horticulture? Pomology, Floriculture, olericulture, landscape Horticulture, Turf management, Postharvest physiology.

Pomology is the branch of horticulture revolves around production and cultivation of fruit crops. Botanically, a fruit is a ripenedovary. The horticulturaldefinition of fruit includes other floral parts as well.But here, fruit· is the edible, fleshy or dry portionof a plant whose developmentis closely associated with the Bower. The commercial production of fruits is known as orcharding. It is typicallybased on long-livedperennials, many of which do not bear fruit untilseveral years after they are planted.

Morphologically, fruits possess three layers. These are:

1. **Exocarp** - This is the outer most layer often consisting of only the epidermis.
2. **Mesocarp** (middle layer) - This varies in thickness among fruit types.
3. **Endocarp** - The inner most layer, which also considerably vary among species.

### 1.2. Classification of Fruits

Horticultural classification is a logically conceived system of description,nomenclature, and identification of plants. There can be several ways toclassify plants, like growth habit, life span, temperature relations, uses,morphology, and cultural requirements. However, the botanical classificationsystem remains the basis of plant nomenclature and identification.

#### 1). Classification Based on the Number of Ovaries and Flowers involved in Fruit Formation

Generally, fruits can be categorized in to three. These are:

**I. Simple fruits-** They develop from a single matured ovary in a single flower.

1. **Fleshy fruits**- at maturity, their pericarp is fleshy. Fleshy fruits can again be divided as:

* **Berry**- consists of one or more carpels with one or more seeds. The ovary wall is fleshy.e.g. date palm, avocado, tomato. Coffee, melon, cucumer, and bananaare berries.
* **Pepo**- An accessory fruit (a *berry* with a hard rind, the receptacle partially or completely enclosing the ovary. Eg. Cucumber, melon
* **Hesperidium**- a specialized berry with a leathery rind.
* **Drupe or stone fruit.** Pericarp distinctly three-layered; epicarpthin, forming the skin; mesocarp fleshy, usually the main edibleportion; endocarp (pip or stone) is hard and stony enclosing singleseed; e.g. mango, sweet cherry, apricot, peach, and almond.
* **Pome**- An accessory fruit derived from several carpells. E.g. apple, pear
* **Hip**- It is also an accessory fruit having several separate carpels enclosed within the fleshy or semi-fleshy receptacle.

1. **Dry Fruits-** These are types of fruits that possess pericarp which dries at maturity. Dry fruits can be:

* **Dehiscent Fruits**- Dehisce or split open when fully mature.
* **Follicle**- Composed of one carpel and splitting along a single suture. Phylogenetically, afollicle is considered the most primitive type of fruit.
* **Legume (pod)**- Composed of a single carpel and splitting along two sutures. Eg. Bean, Pea
* **Capsule**- composed of several carpels and opening at maturity in one or four ways: eg cotton
* Along the line of carpel union (speticidal dehiscence )
* Along the middle of each carpel (loculicidal dehiscence )
* By pores at the top of each carpel (poricidal dehiscence)
* Along a circular horizontal line (circumscissle dehiscence)
* **Silique**- contains two carpels which separate at maturity, leaving persistent partition between them. E.g. Mustard, Radish
* **Indehiscent Fruits-** These are fruits which do not split open at maturity. They can be:
* **Achene-** A one seeded fruit with the seed attached to the fruit at on point only.
* **Caryopsis/Grain-** This is also a one seeded fruit in which the seed is firmly attached to the fruit at all possible points.
* **Samara-** One or two seeded fruits with the pericarp bearing a wing like outgrowth.
* **Schizocarp-** Consist of two carpels which at maturity separate along the middle in to two one-seeded halves (each of which is indehiscent).
* **Lement-** Having several seeds, breaking in to one-seeded segments at maturity.
* **Nut-** A hard, one-seeded fruit generally formed from a compound ovary with the pericarp hard throughout.

**II. Aggregate Fruits-** They consist of ***a number of matured ovaries*** formed in a single flower and arranged over the surface of a single receptacle. **Example:** Raspberry, strawberry

**III. Multiple Fruits-** Consist of ***matured ovaries of several to many flowers*** more or less united in to a mass. They are almost invariably accessory fruits.**Example:** Pineapple

**IV. Accessory Fruits-** Fruits that develop from tissues surrounding the ovary are called accessory fruits. Accessory fruits generally develop from flowers that have inferior ovaries. They can be simple, aggregate or multiple.

#### 2. Classification Depending on Ripening Process

On the basis of respiratory pattern, fruits can be dividedinto two major groups: climacteric and non-climacteric fruits.

#### Climacteric Fruits

The climacteric is a stage of fruit ripening associated with [ethylene](http://en.wikipedia.org/wiki/Ethylene#Ethylene_as_a_plant_hormone) production and [cell respiration](http://en.wikipedia.org/wiki/Cell_respiration) rise. Apples, [bananas](http://en.wikipedia.org/wiki/Banana), [melons](http://en.wikipedia.org/wiki/Melon), [apricots](http://en.wikipedia.org/wiki/Apricot), [tomatoes](http://en.wikipedia.org/wiki/Tomato) (among others) are climacteric [fruit](http://en.wikipedia.org/wiki/Fruit). Climacteric is the final physiological process that marks the end of fruit maturation and the beginning of fruit [senescence](http://en.wikipedia.org/wiki/Senescence). Its defining point is the sudden rise in respiration of the fruit and normally takes place without any external influences. After the climacteric period, respiration rates (noted by [carbon dioxide](http://en.wikipedia.org/wiki/Carbon_dioxide) production) return to or below the point before the event. The climacteric event also leads to other changes in the fruit including [pigment](http://en.wikipedia.org/wiki/Pigment) changes and [sugar](http://en.wikipedia.org/wiki/Sugar) release. For those fruits raised as [food](http://en.wikipedia.org/wiki/Agriculture) the climacteric event marks the peak of edible ripeness, with fruits having the best taste and texture for consumption. After the event fruits are more susceptible to [fungal](http://en.wikipedia.org/wiki/Plant_pathogen) invasion and begin to degrade with cell death.

#### Non Climacteric Fruits

[Citrus](http://en.wikipedia.org/wiki/Citrus), [grapes](http://en.wikipedia.org/wiki/Grape), [strawberries](http://en.wikipedia.org/wiki/Strawberry) are non-climacteric (they ripen without ethylene and respiration bursts). However, there are non-climacteric melons and apricots, and grapes and strawberries harbor several ethylene receptors which are active.

Table 1: Classification of fruits based on ripening process

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Non-climacteric | |  | Climacteric | |
| Bell pepper | Olives |  | Apple | Melons |
| Blackberries | Orange |  | Apricot | Nectarine |
| Blueberries | Pineapple |  | Avocado | Papaya |
| Cacao | Pomegranate |  | Banana | Passion fruit |
| Cashew apple | Pumpkin |  | Breadfruit | Peach |
| Cherry | Raspberries |  | Cherimoya | Pear |
| Cucumber | Strawberries |  | Feijoa | Persimmon |
| Eggplant | Summer squash |  | Fig | Plantain |
| Grape | Tart cherries |  | Guanábana | Plum |
| Grapefruit | Tree tomato |  | Guava | Quince |
| Lemon |  |  | Jackfruit | Sapodilla |
| Lime |  |  | Kiwifruit | Sapote |
| Loquat |  |  | Mamey | Tomato |
| Lychee |  |  | Mango | Watermelon |

#### 3. Classification Based on whether Fruits are Leaf Shedding or Not

**Deciduous-**Theseare fruit plants that lose their leaves under adverse conditions (e.g., cold, dry).Generally, such fruit plants are of temperate origin. Apple, pear, peach, plum, grape etc. are examples of deciduous fruits.

**Evergreen fruits-**Are fruit plants that are never entirely leafless. Most fruit plants of   
the tropical and subtropical origin are known to be evergreen. Banana, pine apple, mango, papaya, guava, citrus, passion fruit, avocado etc. are examples of evergreen fruits.

#### 4. Classification Based on their Origin (Climatic Adaptation)

Fromthe standpoint of crop-plant production, there are four climatic zones: (1) the tropical, (2) the subtropical, (3) the warm- temperate, and (4) the cool-temperate. These zones can be delineated according to their latitude (or distance from the equator). In general, the tropical zone lies 0-20°, the subtropical 20-30°, the warm-temperate 30-40° and the cool-temperate 40-60° north and south from the equator. These differences in latitude may account for the difference in temperature, length of the frost-free growing season, and intensity and duration and length of light between any two zones.

The degree of heat varies more or less directly with the distance from the equator. As a result the tropical zone has the highest temperature, the longest frost-free growing season and the highest intensity of light. This is followed by the subtropical, the warm-temperate, and the cool-temperate zones, in descending order.

* **Tropical fruits:**Fruit plants in the tropical group do not withstand freezing temperatures, and many do not grow well if temperatures drop below 10°C. These plants do not require cold temperature exposure for either vegetative growth or flower initiation.
* **Sub-tropical fruits:**Such fruit crops are grown at low altitudes in those parts of the temperate zones nearest the equator. Most of them can grow in the true tropics, but do not produce well. The majority of mature sub-tropical fruit trees tolerates some subfreezing temperatures but are killed or severely injured below about 9.5°C. Citrus and avocado are examples of subtropical fruits.
* **Temperate fruits:**Fruit crops that are grown in the temperate-zone regions of the northern and southern hemispheres. These plants withstand very cold winter temperatures and do in fact require winter chilling for good productivity. Grape, peach, strawberry, apple and plum are among temperate fruits that are grown in Ethiopia.

#### 5. Classification Based on the Mode of Development of Fruit

* **True fruit-**A fruit that is derived from an ovary (e.g., citrus, grape, guava)
* **False fruit-**A fruit that is developed from an ovary plus associated parts of a flower e.g. Strawberry, apple, pear.

## 1.3. Importance of Fruit Production in Ethiopia

1. **Food value:** Fruits are important due to their carbohydrate and vitamin contribution to the human diet. Most fruits contain large quantities of sugars and are high in vitamins such as vitamin A and C which are not abundant in the staple food of many Ethiopians. Fruits like avocado are rich in fat and other nutrients. Hence fruits are important ingredients to balance human diet. In other words fruits play an important role in the face of prevailing malnutrition problems in many developing countries.
2. **The feed value:** (livestock fodder) of fruits is also important. By-products from processing industries, unusable parts of fruits (e.g., skin of fruit), serve as feed for animals. Flowers of most fruit crops are visited by insects (honey bees) and are excellent sources of pollen and nectar (i.e. bee forage).
3. **Income source:**These days, there is an increasing demand in consumption of fresh and processed fruits locally and the country is also exporting fresh fruits and/or processed products from which a sizable amount of foreign currency is being earned. In addition, increasing fruit production in the country saves foreign currency by substituting imports of fruits from elsewhere. Some local industries (e.g., winery) are still importing fruit raw materials by investing large sum of hard currency.
4. **Medicinal value:**Like many other plants, the medicinal value of fruits is well known traditionally and in modern medicine. For instance, organic acids such as, malic, citric, tartaric, oxalic etc. are some common constituents of fruits known to act in certain cases as mild laxatives.
5. **Employment opportunity:**Expansion in fruit production leads to introduction and establishment of fruit processing plants (industries) which in turn opens a new area of employment.
6. **Raw material source:**Fruits are raw materials for local industries, that is, for processing into various products (e.g., wines, squash, jams, marmalade, jellies, essential oils, etc.).
7. **Decorative and shade value:**Fruits are commonly grown around buildings (or in the Burden) along roads, and in recreation sites mainly to increase the beauty of the surroundings. Fruit trees are also used as a shade for animals (including humans) and (or some shade loving crops in multiple cropping system.
8. **Soil and water conservation:**Fruit plants help to mitigate soil erosion by wind or water; because their roots act as webs to hold the soil in place. Their leaves and brunches may intercept the rainfall and reduce the impact of rain drops (i.e., dispersion of soil particles). The roots improve drainage (infiltration) which in turn increases the amount of water to be stored in the soil thereby decreasing run off.
9. **Fuelwood:**Fruit plants, like other shrubs and woody plants, are known to serve as a source of fuel that provides warmth and energy for cooking. Furthermore, they can be used for construction and fencing purposes.

## 1.4. Present Status of Fruit Production in Ethiopia

Many fruits of major economic importance (e.g., citrus, banana, grape, avocado, mango, papaya, pineapple etc.) in Ethiopia are exotic. They have been introduced to thecountry by missionaries, diplomats, merchants, and native scholars. The exact routeand sources of the introduction is not known for many of them.

Atpresent these fruits are produced at different levels: peasant holdings (smallgardens/ back yards), small scale farms and large scale farms. Normally, peasants use seedlings raised from seeds collected from cultivars of unknown origin. In addition to this, they follow old aged cultural practices (i.e., with no or little input of improved and up to-date agricultural technologies). As a result, not only yield per hectare is low but also fruit quality is poor. Therefore, fruit coming from this sector is mainly used for domestic consumption (self consumption and local market).

Large scale fruit plantations, unlike the peasant holdings, are established using well identified, and characterized cultivars that possess desirable characters. Production is based on improved cultural practices which in turn give good yield and better quality produce. Fruits produced in large scale farms usually meet national and international quality standards. Hence, they are used either to satisfy the domestic demand or to earn foreign currency (i.e., for export).

## 1.5. Challenges of Fruit Production in Ethiopia

1. **Absence of broad genetic base:**As aforementioned most economically important fruit species are exotic (introduced into the Ethiopian agricultural system). The number of cultivars in use is very limited (i.e., the genetic resource bases for further improvement is narrow). Generally, the existing materials in the farmers' hands are of unknown origin, inferior in yield and quality; and prone to pests.
2. **Poor knowledge of the society about the nutritional value of fruits:**Until recent lime, the nutritional advantage of fruits was not well known, and hardly included in daily diets. Even today, the large mass of Ethiopians living in rural areas still considers fruit as a luxury rather than necessity food stuff.
3. **Lack of improved planting material and production technology:**Even though there is an increase in fruit production in the last few decades as a result of the increase in local and export demands, so far there is a lack of improved planting material and production technologies that can help to satisfy the ever increasing demand of growers.
4. **Lack of appropriate post harvest technology:**Generally speaking, fruits are fleshy and/or juicy, and are easily perishable. Aside from problems related to harvesting, postharvest losses of fruits are high due to lack of proper handling and transportation facilities.
5. **Disease and insect pest problem:**Various diseases and insect pests are known to cause serious damage to cultivated fruits. This problem is threatening low input farmers to the extent of discouraging maintenance of established crops or further expansion. For instance at present leaf and fruit spot of citrus (Phaeollamulariaangolensis) is found to be a very threatening (catastrophic) disease to citrus production especially in south western parts of Ethiopia.
6. **Marketing:** In various fruit growing areas of Ethiopia, it has been observed that the harvesting period of most fruits coincide and so local markets often get saturated. This often leads to a drop in price of fresh fruits and so lowers the moral of farmers and discourages better management or further expansion. Because of their perishable nature and bulkiness fruits will lose their quality with time and need to be sold within a short period of time. This, therefore, calls for planning and establishing appropriate postharvest handling facilities in the fruit marketing system.
7. **Poor Infrastructure for transportation**
8. **Limited Research and Extension Service**
9. **Limited Value adding Industries**

## 1.6. Potentials of Fruit Production in Ethiopia

Ethiopia hasdiverseclimateand altitudeconditions which areconduciveto variousagricultural activities. Thereareseverallakesandperennial riversthathavegreatpotentialsforirrigated agriculture.Thegroundwaterpotentialofthecountryisabout2.6billion cubicmeters. Groundwaterin thecountryisgenerally ofgood quality andit isfrequently used tosupply homes andfarmsteads. Thepotentially irrigable landareaofthecountry isestimatedat10million hectares, outof which onlyabout1%iscurrentlyunderirrigation.Mostofthesoiltypesinfruitsandproducing regionsofthecountry rangefrom light claytoloamandarewellsuited forhorticulturalproduction.Endowedwithfavorableweather, altitude, adequate waterandavailability ofsuitablesoils,the potential todevelophorticulturalcrops, such asfruitsis greatin Ethiopia.Fruitcropsofsignificant importanceandwithapotentialfordomesticconsumption,export marketsandindustrialprocessingincludepineapples,passionfruits,bananas, avocados,citrus fruits,mangoes,mandarin, papayas,guava andgrapes areproducedin thecountry.

The future potential of fruit production in Ethiopia may be explained considering the   
following conditions:

1. **Favorable agro-ecological conditions**

* ***Climate****-* Ethiopia contains a mosaic of climatic conditions ("Kolla",   
  "WoenaDega" and "Dega"), with proper selection of sites; it is possible to   
  successfully grow tropical, subtropical and temperate region fruit crops.   
  Besides, the country possesses a great potential to expand fruit farming under   
  irrigation schemes.
* ***Soils***- Most soils in Ethiopia are reasonably satisfactory for the production   
  of quality fruits.

1. **Market**

* **Local markets** - due to increasing awareness of the nutritive value of fruits,   
  fruit consumption (fresh fruit, juice etc.) has increased considerably over the   
  last few years. Such demand is supposed to increase in the foreseeable future,   
  leaving a fertile ground for the local market.
* **Export markets**- Ethiopia is exporting some fruits, notably banana and citrus to nearby countries like Djibouti, Saudi Arabia, Italy and others. Provided there is quality produce, the country has an enormous export market potential from which it would obtain a sizable amount of foreign currency.

1. **Labour**

Horticulturalfarming ishighlabour-intensive,requiring 32to34laborersperhectareperday. SinceEthiopiahasabundantsupplyofunskilledlaboratBirr20-30(US1.17-1.76)perday.

# CHAPTER 2.NURSERY ESTABLISHMENT AND MANAGEMENT

A **nursery** is a place where [plants](http://en.wikipedia.org/wiki/Plant) are [propagated](http://en.wikipedia.org/wiki/Plant_propagation) and grown to usable size. They include [retail](http://en.wikipedia.org/wiki/Retail) nurseries which sell to the general public, [wholesale](http://en.wikipedia.org/wiki/Wholesale) nurseries which sell only to businesses such as other nurseries and to commercial [gardeners](http://en.wikipedia.org/wiki/Gardener), and private nurseries which supply the needs of institutions or private estates.Nursery is established gradually. The mother plants planted for vegetative andseed propagated plant seedlings are raised for sale simultaneously. Important factors considered for establishing a nursery are agro-climatic conditions, soil types, soil pH, location, area, irrigation facilities, communication, market demand, availability of germplasm or mother plants, etc.

# 2.1. Nursery Site Selection

**Criteria for nursery site selection**

* The nursery site should have a flat or gently sloping surface
* The area should have light to medium soil and should be well drained, to a depth of at least 1 m
* The location of a nursery site or propagation plot should be
* Separated from the production field
* Located as close as possible to fruit-producing areas
* On land which was not previously planted under the same fruit crop, to avoid Build-up of diseases and other pest population
* Outside the range of roots and shade of trees, hedges and buildings
* In an area not prone to frost
* Near a source of water for irrigation
* Protected from strong winds and
* Readily accessible by all-weather roads for the transport of plants (seedlings)
* The nursery area should be fenced and kept clean from weeds within and around the nursery which otherwise may host pests (diseases, insects and others); and
* Rotation of nursery site- Once the soil in the nursery has been used there is always a risk of it harboring diseases and other pests which will infect a second crop of seedlings. If diseases and other pests are observed on the seedlings raised in the nursery, then the site should not be used again until it has been rested and fumigated.

If pests have not been observed on the seedlings, then the nursery site can be used for the second time provided that the fertility is built up with well-rotted organic matter and mineral fertilizers such as superphosphate.

## 2.2. Nursery bed preparation

**Nursery soil preparation-**Nursery production requires a fertile, well-drained soil of medium texture. Preparation of soil for planting may include rotation with other crops and incorporation of a green manure or animal manure. Pre-plant fumigation of soil and weed control are essential aspects of most nursery operations. A common size of seedbed is 1.1 to 1.2m wide. The length varies according to the size of the operation (commonly, the minimum is 5 m). Beds may be raised to ensure good drainage. The nursery beds will be prepared for storing of perennial plants or the plants that should be kept for sale.

## 2.3. Fruits Nursery Operation and Management

**Time of planting***-* is based mainly on the dormancy conditions of the seed, the temperature requirements for germination and the management practices at the nursery.

**Depth of planting-**is a critical factor that determines the rate of emergence and perhaps stands density. If too shallow, the seed may be in the upper surface that dries out rapidly; if too deep, emergence of the seedling is delayed. Depth varies with the kind and size of seed and, to some extent, the condition of the seedbed and the environment at the time of planting. Type of germination also influences depth of planting, for instance cherry seeds (one of the deciduous fruits) have *epigeous* germination (the cotyledons are above ground) while peach seeds have *hypogeous*germination (the cotyledons remain below the ground). Shallow planting is often used for plant species that have epigeous germination.

As a guide, seeds should be planted at a depth two to three times their diameter and should be covered firmly with soil. The soil should then be kept moist but not wet until the seedlings have emerged. The soil should not dry out completely at any time during the germination period. Equally important is that it should not be too wet so as to avoid an outbreak of *damping off.*

The optimum seed densitydepends primarily on the species but also depends on the nursery objectives. Where fruit plants are to be budded or grafted in place, the width between rows is about 1.2m and the seeds are planted 7.6 to l0cm apart in the row. Seeds known to have low germinating ability must be planted closer together to get the desired stand of seedlings. Large seed (e.g., avocado) can be planted 10 to 15cm deep, medium-sized seed (e.g., citrus, bullock's heart) about 7.6cm, and small seed (e.g., guava, passion fruit) about 3.8cm. Spacing may vary with soil type. If germination percentage is low and a poor stand results, the surviving trees (seedlings) may grow too large to be suitable for budding. Fruit plants to be grown to a salable size as seedlings without budding could be spaced at shorter intervals and in rows closer together.

**Propagation structures**

Structures range from simple shade house to complex and automated greenhouses, which vary in the extent to which they control the environment. Propagation structures are desirable in a nursery because they permit the nursery worker to control the environment. The size of the propagation structure also influences the comfort of the workers attending to the seedlings (or nursery).

A simple shade structure can be constructed by using poles to support a roof of wire mesh or other locally available appropriate materials on which a thin layer of thatching grass is tied to give filtered sunlight beneath. Poles should be treated with a wood preservative to prevent rotting and termite damage. The structure can be used to propagate many species and for growing newly transferred (pricked) stock.

**Potting Soils/Media**

The soil used to raise seedlings should be fertile and should drain well. Once a suitable collection site has been identified, clear the surface of weeds, leaves and other litter, then dig out the topsoil to a depth of about 10 cm deep. Remove any stones and roots, ideally be sieving. Then mix 2 parts of soil with 1 part of manure or compost and 1 part of sand (if available).

A good potting soil must meet a number of conditions if high quality nursery stock is to be produced. **Firstly**, a mix must adequately support the plant. This means that it must be heavy enough to prevent the plant from falling over, without being so heavy that handling and shipping costs are unduly increased. **Secondly** the mix must provide a reservoir for air, moisture and nutrients. Air and moisture compete with each other to occupy the spaces between the particles of the mix. Water tends to occupy small spaces while air occupies large spaces. For this reason the size of the spaces between soil mix particles is very important. In the ground most clay-containing soils will aggregate or clump together in such a way that there is space for both water and air.

However,when soils are transferred to a pot (plastic tube), the aggregated particles are usually destroyed (dispersed) and only very small spaces remain.Hence the soils do not contain sufficient air for good growth of plants. For this reason field soils are almost never good potting soils unless they are amended to increase their aeration. If the roots of potted plants reach near the soil surface, or occur near the sides of the planting pockets, or near drainage holes seedlings grow much more slowly than is desirable. Besides, owing to low oxygen diffusion and wet conditions, the likelihood of root rot diseases may increase.

The soil mix must, however, hold sufficient quantities of water since the root system is confined to a small container. Otherwise seedlings need to be watered frequently. For this reason, soil mix must contain water absorptive materials. Many types of organic matter (preferably compost) are very efficient in this regard.

**Thirdly**, the mix must supply all the nutrients the plant needs-both macro- and micro- nutrients. These nutrients have to be added to the mix and pH adjusted to an optimum level. In addition to aforementioned requirements for a soil mix, condition of pests and heavy metal contamination deserve due attention. Furthermore, soilmix should be stable enough to ensure that its properties do not change drastically during the period of time that the plant is in the nursery. Materials which tend to compact or organic matter which tends to decompose rapidly are usually not satisfactory ingredients in soil mixes: because, although they may perform satisfactorily initially their influence (or effect) will change drastically with time.

The last but not least desirable attribute of the soil mix is its standardization. A precise recipe should be used in making the mix (e.g., soil, sand, compost, nutrients) and these same ingredients should be used each time the mixis made.

**Raising seedlings in plastic tubes**

Thistechnique has been developed for raising seedlings which will not be transplanted under optimum field conditions, for kinds which are difficult to transplant bare root (i.e., for seedlings whose roots are sensitive to environmental conditions); and seeds of high value such as " **Solo***"* papaya.

The filled plastic tubes (polythene tubes) are arranged close together in a standard sunk seed bed (in Ethiopia, lx5m, seedbed is common) so that the bed can be easily- irrigated and to let the water percolate into the tubes from beneath.

Two general sequences of operation are followed in the initial establishment of the seedling plants to be grown in containers: direct seeding and transplant method.

**Direct seeding:-**Seed may be placed at the desired spacing in a seed flat or directly into an individual container. Direct seeding is used mostly with medium- or large-sized seeds or those for which transferring (or pricking) them to wider spacing within the nursery, so as to improve their growth before being transplanted to the field, is particularly harmful. One or two seeds are sown in each tube (container). The surface is then covered with dry grass and hand watered. The grass (mulch) is removed as soon as the seedlings emerge above the soil level. Seedlings are transplanted to the field as soon as small roots can be seen emerging from the bottom of the tube or else the roots need to be pruned. At planting the tube should be slit down on one side to avoid any construction of the root system.

**Transplant (pricking) method:-**In some cases, it is desirable to transfer young plants into containers of various sizes as an intermediate stage between the seed or cutting and transplanting to permanent sites. This practice is often followed in the case of mango, avocado and guava rootstocks (which are to be grafted later). In general the practice is necessary for plants which have to be transported long distances to permanent sites.

**Watering***-* The seed beds should be watered immediately after sowing. Examine the seed beds daily and apply water if the surface of the soil becomes at all dry. At the stage when the seedlings reach a height of 5 cm, thinning should be carried out if necessary and watering should be changed to surface irrigation if overhead irrigation will not be continued. The water must be admitted slowly through siphons or tubes to the bed and should not exceed a depth of 2 cm. Frequency of watering will depend on local conditions. The beds should be examined daily and re-watered if necessary.

**Fertilizer application-**The type and rate of fertilizer to be applied should be based on soil analysis of the nursery site and the requirement of the species.

**Wind breaks***-* In windy places, it is advisable to establish temporary windbreaks at 50m intervals in the nursery. A suitable temporary windbreak can be made by sowing a single line of pigeon pea, with the seeds spaced at 50 cm in the row. Protection from wind will increase the rate of growth and reduce wind or related damage to plants.

**Weeding:** Weeds are a threat to healthy seedlings development. They compete with seedlings for nutrients, water and light hence they must be controlled. With your hands or a dibble gently pull out unwanted growth (rouging) this should be done whenever weeds are observed. Remove all the weeds around the beds with a jembe and don’t leave any rubbish around unless you are sure that this can be converted to compost.

**Plant protection***-* Plant protection in the nursery includes the disinfecting of soil to prevent soil-borne diseases as well as spraying of fungicides and insecticides to control fungal and bacterial diseases and insect pests on seedlings. The control measures differ according to the crop. Selective removal of diseased seedlings (crossing) is also common practice in nursery pest management.

**Root pruning:** Root pruning is the cutting of roots to control root system development beyond the container. Why root prune? When seedlings have reached to a certain size and their roots become longer than the depth of the pots. If the roots are left without pruning, they penetrate into the ground and develop the root systems there. Once the root system develops under the ground, it is hard to move the pots, and if the roots are cut when the seedling is old, the seedlings will be weakened; hence periodical root pruning is required before the root system reaches into the ground. The period and interval of pruning depends on different species and other conditions. Root pruning should be done regularly preferably every 2 –3 weeks.

**Procedure**

* Water the seedlings properly before root pruning.
* Using a sharp knife or wire or scissors to cut the long roots underneath the container. You can also uplift the containers (wrenching) to cut overgrown roots.
* Water the seedlings well after root pruning. This helps the plant withstand moisture stress.
* Note that to reduce root pruning, you can Place the seedlings on a bed of stones or on polythene sheet and this reduces root development.
* If the seedlings are in a raised bed, prune the roots by using a panga, knife or wire underneath the bed, soon after watering see below

**Hardening off:** Hardening up is to expose the seedlings to harshconditions to make them strong so that they will be able to survive underharsh climate in the field after planting out. It is also a gradual preparation ofseedlings for field conditions.

**Hardening up process:**

* When the seedlings grow and reach the planting size, the shade should be removed to exposure to more sunshine
* Reduction in watering intensity (quantity) and frequency-water twice a week and later once a week
* Before planting out, root pruning should be carried out frequently or re-arrangement of pots to allow more adoption to stress.
* Good preparation for out planting results in good field survival, therefore hardening off should be done 2 – 3 weeks before out planting time.

**Postponing planting:** If it’s not possible to plant when the seedlings are ready for planting out (reached right size for planting-1.5 ft) or the seedling are not bought; cut the tips of the plant to suppress further growth so that they will not be overgrown during next season planting.

**Grafting and budding of fruit plants-**Fruit seedlings or cuttings are normally grafted or budded onto a desirable rootstock under nursery condition, where they will be well protected from adverse conditions. Because grafting and budding of fruit trees are specialized operations, experienced workers are needed to get the best results.

Nursery plants can be delivered for field planting in several ways: with sleeved soil (a soil ball) or bare-root, pruned and stripped of leaves or with leafy branches. The method preferred depends on climate and other conditions. Transport of course, is far cheaper with bare-root plants, but they run the risk of drying out, distortion, breakage, or infestation. Therefore, this can only be done in a wet season, over short distances and when the plants can be set out immediately. With bare-root and leafless plants the risk of transporting diseases, nematodes and scales from nursery to field is decreased. In most cases pruning (capping) is needed in the nursery, in order to start a framework of branches.

**Transplanting to permanent location-**The final step in nursery production is transplanting seedlings to their permanent site (orchard). The seedlings may be transplanted either with bare roots or with the soil ball containing the roots.

Bare root transplanting invariably undergo root damage and transplant shock, which may affect establishment and/or plant growth. The use of the soil ball minimizes transplant shock. In both cases success in transplanting depends to a large extent on the previous handling of the plants. The operation requires that the plant be hardened prior to its shift to the open field. Hardening involves a checking of growth resulting in the accumulation of carbohydrates, which makes the plant better able to withstand adverse environmental conditions. This can be achieved by the temporarily withholding moisture and minimizing the level of the nursery shade (this practice is commonly called hardening) for a sufficient period of time. Beforebeing moved into the field, the plants should be watered thoroughly. Planting is done in the field by hand or, in some cases, by transplanting machines.

**Temporary storage of bare root seedlings-** If the seedlings cannot be planted soon after delivery, a trench can be dug in a shady location and the roots covered with moist soil.

**2.4. Methods of growing fruit Seedling**

**Growing seedlings in a field nursery**

Nursery row cultureis a basic nursery operation used for outdoor seed propagation of fruit trees. Rootstocks of most fruit and nut species are propagated by planting directly in nursery rows. Cultivars arebudded or grafted to the seedlings in place.

Propagation fruit crops are propagated sexually by seed and asexually by vegetative materials.

**Seed:-**seeds develop when an ovule if fertilized by a pollen grain. The ovary becomes a fruit and the fertilized ovule seed under natural conditions, the daughter plants produced from a seed is never an exact replica of the parent plants. Papaya, guava, and root stock materials of woody fruits such as citrus, mango, and avocado are propagated by seed. Root stock propagation by means of seed has great advantage over vegetative propagation that it entails rather less work. However, the main disadvantages of seedlings are their propensity for variation and the impossibility of predicting the limits of this variability.

**Vegetative material:-**vegetative materials for propagation may come from any portion of the plant except the seed (stem cuttings, roots, corms and leaves). Vegetative propagation produces plants with the same characteristics as the parent plants. Some of the fruit crops produce vegetative materials naturally.For example,banana (sucker), strawberry, and pineapple (slip, crown). However, mango also uses vegetative propagation to produce plants which are similar to their parents by grafting, cutting, layering etc. However, budding and grafting are the most commonly used practices for the major fruit crops.

**Raising Root Stock Seedling**

Can be raised either on seed bed (1m\*5m) size is in poly bags (with drainage holes at the bottom) filled with different growth media mix (sand, manure, forest soil). Seeds should be planted at appropriate depth and position. seed germination may take up to one month depending of the temperature (the higher the temperature the faster the germination will be type of fruit crops and the verity seed should be under partial shade and seedlings are transplanted when they reach appropriate size. Seedlings can be ready for grafting about six months after planting on the nursery bed or polybags. The most common types are:

**1) Budding**: In ornamental Horticulture, mostly 'T'-budding or 'Shield' budding is employed for propagation.Eg.Orange, Avocado etc.

**2) Grafting:** It is one of the many methods of asexual propagation where two parts (varieties) are joined to make one plant. The main advantages of grafting include shorten juvenility/early fruit bearing, increase quality of scion and rootstock (disease, soil pH etc) manageable tree size and true-to-type.for instance, a cultivar may give high yield of excellent fruits, but may be susceptible to soil born diseases, but another cultivar on the other hand, may be resistant to soil born diseases but, poor yielder. Thus combing of the desirable characteristics of the two cultivar in one tree using grafting gives a tree that is resistant or tolerant to the soil born disease and the same time gives high graft and compatibility of scion and root stock needs skill and special tools, danger of disease introduced or susceptible to physical damage (wind, animal) especially at early stage and needs wider area is for establishment of foundation blocks. Mostly the root stock and the scion come from two trees of the same species, but of different cultivars.

Occasionally, trees of different species, but of the same family can be grafted successfully. In most cases grafting is done in the nursery. During grafting cares on proper selection and in the preparation of scion, mulching scion thickness with the stock and scion bud stick maturity isneeded.

**CHAPTER THREE: ESTABLISHMENT AND MANAGEMENT OF ORCHARDS**

## 3.1. Orchard Site Selection

Each species of fruit has specific environmental requirements which must be met for optimum growth and production. Land survey is a very important prerequisite for the foundation of a new farm or re-organizing an existing one.

Major aspects of land use planning which should be investigated are climate, soil, vegetation (natural) and previous cropping history, topography, irrigation potential, infrastructure, logistics and communications in relation to markets.

Itis extremely important to learn as much as possible about the weather of the proposed planting site. Meteorological information can often be obtained from neighbors who have lived in the area for many years, national meteorology (government weather services) or any other sources. Several weather conditions (climatic factors) are particular importance in fruit growing.

**Temperature**:is one of the most important environmental factors influencing the growth and development of fruit plants and fruit quality. The favorable temperature range for the growth and development of any particular fruit plant is known as the *optimumtemperature range.* Within this range the two fundamental processes, photosynthesis and respiration, are proceeding in such a way throughout the life cycle of the plant that the highest marketable yields are produced, Therefore, the intended orchard site should have the optimum temperature range for successful growth and development of the fruit (s) to be grown.

The optimum temperature range vanes from one fruit crop to another. In general, some crops have high rates of photosynthesis combined with normal rates of respiration with in a relatively low range, and other crops have high rates of photosynthesis combined with normal rates of respiration at a relatively high range. On this bases, Edmond *et al.*(1983) classified fruit plants as follows: (1) fruit crops which produce their highest yields at a low temperature range (7 – 13 °C), (2) fruit crops which produce their highest yields at a moderately high temperature range (l3 – 18 0C), and (3) fruit crops which produce their highest yield at a high temperature range (18 – 24 oC). The optimum temperature range for some fruit crops is shown below.

Temperature requirements of some fruit crops

|  |  |
| --- | --- |
| Optimum temperature range | Fruit crops |
| Low temperature range (7 – 13 oC) | Apple, pear, plum, strawberry |
| Moderately high temperature (13 – 18 oC) | Peach, nectarine grape, blackberry, tree tomato |
| High temperature range (18 – 24 oC) | Banana, citrus, mango, papaya, fig, date |

**Rainfall**:fruit plants require adequate soil moisture throughout the growing season. Amount and distribution of the annual rainfall can vary widely from place to place. Some areas receive relatively small quantities each year (arid and semiarid) whereas others receive large supplies (humid). In the arid and semiarid areas (where rainfall is erratic and scanty) the application of irrigation water is required for the production of high yields. Conversely, humid areas receive sufficient amounts of rainfall per annum. Since effectiveness of rainfall is more important than amount, the application of irrigation water may serve as insurance for the production of high yields. A better situation exists where water supplies for irrigation are available during times of drought.

A pattern of continual rains during the pollination period could result in poor crops by interfering with bee activity. Continual rains during the fruit harvesting period leads to problems, not only in harvesting operations but also in promoting various fruit disease (fungi, bacteria).

The proposed site should not be subjected to periodic flooding (from nearby rivers or streams, faulty irrigation, poor hydraulic conductivity), Most fruit plants will not tolerate water around their roots for any length of time, as the water stops air penetration to the roots.

**Wind**: It is detrimental from several aspects. It can damage young, tender shoots and can scar- bruise young fruits. Reduced bee activity during windy days in the pollination season can seriously reduce fruit set and yields. Windbreaks can help reduce this problem. Sites that have a history of strong winds should therefore be avoided.

***Hail:***The frequency at: hailstorms at the proposed site should be determined in advance, as they are very damaging especially to soft fruits such as strawberry, peach, etc.

***Elevation:*** The elevation of the land refers to the altitude of the surface of the land above or below sea level. Differences in elevation make for marked differences in temperature between the two places. Altitude and temperature are inversely related, that is, the higher the altitude the lower the temperature of the site and vice versa. In the tropics for every increase in elevation of 100m, there will be fall in temperature of 06°C.

Tropical fruit crops thrive at the low elevations; subtropical fruit crops thrive at the intermediate elevations; and warm- temperate and even cool-temperate crops thrive at the high elevations.

**Soil characteristics:**The soil should be investigated very thoroughly to assess its suitability for fruit production. Soil type, texture, structure, permeability, drainage and reaction (pH), content of essential elements, organic matter and soluble salts are important factors to be considered when selecting a site for fruit crop production

The ideal orchard soil should be deep at least 1.8m, well-drained, non-saline, fertile, clay loam to a fine sandy loam. The surface should slope gently, allowing for the removal of runoff (from heavy rains) and permitting good infiltration of irrigation water.

**Topography:** The principal factors are the slope of the land, its aspect, exposure to wind, liability to frost hazard and effectiveness of the natural drainage system. The suitability of land for different purposes can be determined by a study of topography. The degree of land slope will generally decide its suitability for different types of fruit crops. Provided a suitable layout is used to protect the soil against erosion, fruit crops can be grown on land which has up to 17% slope. Level or gently sloping land is most suitable for annual fruit crops (e.g., strawberry) or short-term perennials such as pineapple, provided- drainage is satisfactory. More sloping sites can be used for long-term perennial fruit trees. Very steep slopes and broken land should be reserved for permanent pole and fuel plantations which will also have the effect of decreasing runoff.

**Vegetation:**The natural vegetation is determined by climate, soil, topography and pests. In many cases the primary vegetation will have been destroyed by cultivation or drastically changed by over-grazing. It is important to investigate previous land use for cropping or grazing and to observe whether serious soil erosion has occurred. Much can be learned about soil conditions on previously cropped land by observing the kind of weeds which are growing on it.

**Availability and quality of irrigation water:**In low rainfall areas, assurance should be obtained that there is a potential source of ample high-quality irrigation water. Water samples can be analyzed by standard laboratories for the level of soluble salt and water borne diseases.

**Communications:** Telephone/ radio link, farm access roads, distance from main roads, railway ports, markets and processing plants.

**Services**: Availability of human-power, housing, farm buildings, electric power, water supply and social amenities.

**Land improvement:** Soil conservation and irrigation system, land leveling and grading, windbreaks, fuel and pole plantations, and established perennial crops.

**Logistics and communications in relation to markets:** The distance to markets, ports and processing plants (industries) should be within an economically feasible range. New processing plants, grading and packing stations, cool stores, etc. should be located inthe centre of a fruit production area. The road system within a farm should be planned in conjunction with the windbreak system, and should be in accordance with the quantity of produce to be transported.

## 3.2. Land Preparation

Thepurposes of land preparation are:

* Level the land where needed
* To Incorporate crop residues, green manure and cover crops; prepare and maintain a seedbed in good tilt
* To control weeds, diseases, and insects
* To improve the physical condition of the soil, and
* To control erosion where needed

Fruit crops may be established on new (virgin) and/or cultivated land. New land which is selected for fruit crops production must be cleared of primary vegetation,stones and perennial weeds (usually a year before the planned planting time). The second operation must be leveling or grading. This is a very important operation for the permanent cultivation of fruit crops, especially for surface irrigation layout. Rough leveling is carried out by bulldozers followed by fine leveling with land-graders or land-levelers.

The development of new land should be carried out by a contractor since the necessary machinery is too expensive for a single farm. Where the subsoil is strongly alkaline, grading must be reduced to a minimum.

Ploughing can be done by disc ploughs, mouldboard ploughs, or rotary cultivators. For ploughing fields for fruit production, the mouldboard plough or the rotary cultivator are preferred because of their better working quality compared with the disc plough.

A recommended soil preparation for deep-rooted fruit crops are sub-soiling (about 90 cm deep), deep ploughing, levelling and ploughing again.

After using mould board ploughs, land should be disked and harrowed diagonal to the direction n of ploughing. The aim is to break down clods and to reach an even and finely tilled soil surface.

Though fruit trees are deep-rooted, it is not necessary to prepare the soil to the full depth of their ultimate root penetration. In most cases, it is sufficient to prepare the plallting holes. In some cases, zero or minimum tillage can *also* be used, especially for shallow rooted, short-term perennials such as pineapple, provided that other growing conditions are optimum. Cultivating the whole field (orchard) is not done except in cases where cover crops are to be grown and incorporated into the soil. Since young fruit trees do not have sufficient roots or large enough canopies to prevent erosion, a ploughed orchard can expose soil to erosion. For this reason the ground between rows of trees should be grassed and mowed or slashed periodically. Only the area within 1–2m of the tree itself is kept completely free of vegetation, but this should be mulched.

On slopes of *10-15* % (in some cases up to 17 %), well maintained terraces are necessary to prevent soil erosion. Generally, combinations of ridging, terracing, and cover crops are necessary in the tropical orchardifsevere erosion is to be prevented.

Fencing is an important feature of an orchard since young trees are likely to be eaten by animals if they are not protected. In addition, when trees begin to fruit, theft may become a problem. Fencing will help to alleviate both of these problems. However, in Ethiopia fencing is normally accompanied (supported) by alert day and night guards, and the result is said to be quite satisfactory.

**Windbreaks***-* Wind can have a definite harmful effect on fruit production. Where this is a serious problem, windbreaks must be used to decrease the wind velocity and thereby damage to plants. It is well known that windbreaks can result in a 45-60 percent reduction in wind velocity as well as reducing transpiration by as much as 65 per cent (Rice *et at,* 1990).

Ideally, windbreaks should be planted two to three years before the orchard is established so that they are sufficiently large to provide immediate protection to the newly planted orchard trees. The choice of the windbreak species depends on the location of the orchard. Windbreaks should not serve as an alternate host for pests that can attack fruit plants intended to be grown; it should be a tall and multipurpose tree which is strong enough to resist the impact of wind. It should be densely planted to block the wind.

## 3.3. Planting System

Prior to ordering the planting trees, an orchard and/or vineyard plan should be drawn on paper to show the location and cultivar name of each tree, irrigation system (if applicable), trellises or tree supports, orchard roads and paths, packing shed and any other permanent features of the plantation site. If the plan is drawn properly, the number of plants, stakes, and so on can be determined and obtained before the start of planting.

Different planting systems are used in fruits depending mainly on topography of the land, the growth habit of the tree, method of training/pruning and the type of machine intended to be used for the various farm operations.

**Square planting-**In this type of planting system fruit plants are arranged equidistant between plants and between rows. It is usually recommended for plantation site with a slope up to 5%.The square planting system is easy to layout and orchard operations (cultivation, irrigation, harvesting- hand or mechanical) can be conducted in either direction.



**Advantages**

1. Irrigation channels and paths can be made straight.
2. Operations like ploughing, harrowing, cultivation, spraying and harvesting becomes easy.
3. Better supervision of the orchard is possible as one gets a view of the orchard from one end to the other.

**Disadvantages**

1. Comparatively less number of trees are accommodated in given area.
2. A lot of space in the centre of each square is wasted i.e, certain amount of space in the middle of four trees is wasted.

**Rectangular planting-**Unlike the square, in this system the spacing between rows and between plants is not the same. Commonly this planting method is practiced on sites with slopes of 5 – 8% range. Trees with lateral inflorescence, such as citrus and avocado, can just as well be set out in a rectangular planting system.



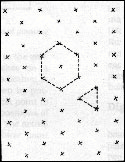
**Advantages**

1. Intercultural operations can be carried out easily.
2. Irrigation channel can be made length and breadth wise 3.Light can penetrate into the orchard through the large inter spaces between rows.
3. Better supervision is possible.
4. Intercropping is possible.

**Disadvantages**

1. A large area of the orchard between rows is wasted if intercropping is not practiced.
2. Less number of trees are planted.

**Hexagonal or Equilateral triangular-**Trees with circular crowns (e.g., date palms), are best planted in an equilateral triangular planting system, This allows cultivation in three directions and accommodates some 16 percent more trees per ha compared to the square system .If the distance between trees is d, then a tree takes up . Let us put d at 10m. Using square planting, 100 trees/ha can be planted. In an equilateral triangle a tree occupies 1/2 x 100 x 1.73 = 86.5m2, so the density is 10,000: 86.5= 116.



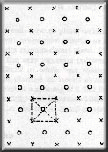
**Advantages**

1. Compared to square system 15% more trees can be planted.
2. It is an ideal system for the fertile and well irrigated land.
3. Plant to plant distance can be maintained the same.
4. More income can be obtained.

**Disadvantages**

1. Intercultural operations become difficult.
2. Skill is required to layout the orchard.

**Quincunx***-* is a variation of the square system. An extra tree, often a temporary one is set in the center of each square. The quincunx planting system increases returns per hectare considerably over the square system in theearly years of the planting while the trees are still small. With this system of planting the center tree must be pulled out to give the full space to the permanent trees, when competition for space is becoming evident at the latter growth stage.



**Advantages**

1. Additional income can be earned from the filler crop till the main crop comes into bearing.
2. Compared to square to square and rectangular systems, almost double the number of trees can be planted initially.
3. Maximum utilization of the land is possible. Approximately 10% more plants than the square method

**Disadvantages**

1. Skill is required to layout the orchard.
2. Inter/filler crop can interfere with the growth of the main crop.
3. Intercultural operations become difficult.
4. Spacing of the main crop0 is reduced if the filler crop is allowed to continue after the growth of the main crop.

**Contour planting***-* This system is used on rolling slopes or hillsides where some terracing may be needed. In this type of planting system, considerable care must be taken to stop erosion by heavy rains or by irrigation through diverting the water to run along the tree rows rather than directly down slope.

**Advantages**

1. This system can be adopted in hilly regions; can control the soil erosion and helps simultaneously in the conservation of water.
2. Preservation of plant nutrients which are supplied as manures and fertilizers.

**Disadvantages**

1. Laying out of contour lines is difficult and time consuming.
2. Special skill is required to layout this system.
3. Special instruments are required for making contour lines.
4. The row to row distance will not be equal and adjustments may be required in the plant to plat distance.
5. Rows are broken in to bits and pieces.

**Hedgerow planting-**is known to be best for dwarf deciduous trees and requires special pruning and training techniques. The primary advantages are high yield and low labour requirements per hectare,

There isnow a growing interest in dwarf trees because this allows for high plant density per unit area and yield. Tile advantages of this are much higher early yields, and less expense in picking the fruit, and spraying and pruning the trees.

Plant distance within and between rows depends on several factors. The major ones may be as described as follows:

**The ultimate tree size of the species and cultivar at maturity:**Dwarfed trees (e.g., spur type apple) will not get nearly as large as those of the strong-growing, vigorous type tree species and, therefore, can be planted much closer together.

**The type of rootstock used**:Fruit trees on the most invigorating rootstocks would need to be planted farther apart than those on the most dwarfing rootstocks.

**Soil fertility-**Here one must consider whether a planting site has a sandy, shallow, infertile soil, where the fruit trees would be slow-growing and never get very large or has it a deep, highly fertile clay loam, where the trees are likely to reach their maximum size. Wider spacing should therefore be given to fruit trees that are to be grown on fertile lands.

**The planned tree density***-* This factor is under the grower's control. In recent years, the so-called high-density orchard plantings, particularly with apples and to a lesser extent with citrus and pears, have become popular.

Generally greater spacing would be used with conditions of high soil fertility, long growing seasons, vigorous, large-size cultivars, invigorating rootstocks, ample rainfall or irrigation, and heavy use of fertilizers; spacing would be closer in the opposite situations.

## 3.4. Laying out the field and digging holes for planting

An important operation in the preparation of the planting site is the laying out of the field. The laying out operation consists of locating planting sites or positions on the field. Materials required for this purpose are ranging poles, measuring chains or tapes and pegs or stakes to mark the planting site.

A baseline is adopted at one side of the block in which the planting sites are to be marked. Along this baseline, the various sites are marked at the appropriate distances required for the crop to be planted. If the planting is to be done on the square, prior to planting right angles should be set out using a rope measuring 3m, 4m and 5m in accordance with Pythagoras' theorem planting holes are staked out and large holes 0.6m and 0.6 m width and depth respectively are dug; topsoil should be placed in one pile and subsoil in another. The hole should then be refilled with a mixture of 50 percent topsoil and 50% well-rotted manure, compost, or other decomposed organic matter. In soils where phosphorous is lacking, super phosphate should also be added as the hole is filled. The hole should be allowed to settle for several weeks and then planting can begin.

Bare root plants must be kept cool and the roots must be kept moist and protected from the sun. When the bare-root trees arrive, they will be wrapped in banana leaves (where available), plastic, or some other moisture-conserving material. After they are unwrapped, the roots should be immersed in water for a few hours before being planted.

In planting, some of the soil is removed from the previously prepared hole and a cone- shaped pile of soil is placed in the centre. The root system is trimmed to remove damaged or diseased roots and is then spread in the hole. Roots should not be kinked or bent, but should be arranged as they would if grown naturally. The hole can then be refilled, taking care that air spaces do not remain around the roots by firming the soil at regular intervals during the operation. The plant should never be set lower in the field than it was in the nursery. As the soil has to settle, it is sensible to plant about 10 cm higher than the ground level. The last step is to prune off half to a third of the top shoots to compensate for the loss of roots which occurred in the digging-up process. Failure to prune will result in weak growth during the first year and an increased incidence of plant death.

Container-grown plants should be removed from their pots (or polythene tubes) and any circling roots should be cut off. Soil is removed from the prepared holes and the plants are then set and covered to the same depth that they were growing in the container. Planting is carried out at the beginning of the rainy season.

The most critical period in the life of the orchard or vineyard is the first year after planting. During this time it is important that plants are not allowed to dry out and need to be protected and are kept free from insect and disease infestations.

Mulching is a beneficial practice both to prevent weed growth and to conserve soil moisture. Mulches can be of any organic material including dried grass, banana leaves, chopped plant refuse, and the like. To be most effective, mulches should be ill least 10 cm thick and should be placed in area 1 – 3 min diameter around the tree but not touching the trunk itself.

## 3.5. Irrigation

Water requirements of fruit plants vary widely by species and varieties, climates, seasons, soil conditions, and methods of application. Best results are obtained when the water requirements of the fruit crop grown in a given area and climate are determined first, then the soil moisture content monitored so that the proper amount of water can applied to ensure an adequate supply of available water.

**Methods of application**

The method of application is important, especially if the cost of water is high. Some factors that determine the method and type of system used are: climate, type of crop, cost of water, slope conditions, physical properties of soil, water quality, water availability, drainage capability, and salinity or other problems.

**Flood irrigation***-* is used where the topography is flat and level. The land must be graded and leveled for flood irrigation, Orchards and vineyards are sometimes flood irrigated. However, this type of irrigation may cause suffocation to the root system of fruit plants and is uncommon.

**Basin irrigation***-* In this type of irrigation water is applied to each fruit plant using a ring type structure made around the plant. It is commonly practiced to irrigate young trees and is changed into the furrow irrigation when the trees get bigger. Water should not touch the trunk.

**Furrow irrigation*-***is a modification of flood irrigation and is confined to furrows rather than wide checks. Water is used more efficiently with furrows than with flooding because the entire surface is not wetted, thus reducing evaporation losses. Long furrows are known to cause greater loss of water because of deep percolation and excessive soil erosion at the head of the field.

The depth of the furrow should be such that the water can be controlled. Water should flow in the furrow for sufficient time to let it percolate across the bed, wetting the surface but not leaving the plant standing in water. For most orchards, furrows from 20 to 30cm deep provide the necessary control.

**Sprinkler irrigation*-*** This type of irrigation is often used when flood or furrow irrigation is impractical. Sprinklers are selected over other irrigation methods mainly because of: (1) soil topography i.e. preferred to irrigate sloping lands; and (2) water costs i.e. preferred where irrigation water is scarce and expensive.

Generally, less labor is needed with sprinklers than either flood or furrow irrigation but the equipment and energy costs are higher.

**Drip or trickle irrigation***-* is the latest development in irrigation systems. Small amounts of water are allowed to trickle slowly into the soil through mechanical devices called *emitters,* wetting the soil without runoff.

Emitters are connected to a small plastic lateral tube, laid either on the soil surface or buried just beneath it for protection;the lateral lines are connected to a buried main line that receives water from a head source. The head source is the control station for the system. Here the water is filtered, can be treated with fertilizers, and regulated for pressure and timing of application.

Some advantages of drip irrigation are:

* Smaller lines than for sprinkler or furrow irrigation;
* Little interference with orchard cultural operations because much of the soil   
  surface is not wetted;
* Less fluctuation of soil moisture because of the constant and slow drip application of water; and
* Less water needed to grow a crop,
* Some objections (disadvantages) of the drip irrigation are:
* The expensive filtration equipment needed because emitters clog frequently;
* Uneven water distribution on hilly land - more water from lower emitters; less from higher ones;
* Salts tend to concentrate on the soil surface because little water is moving downward to keep them washed from the root zone; and
* The foraging ability of roots is restricted to the small volume of wetted soil.

## 3.6. Mulching

Mulching is covering the soil surface by spreading layers of straw, leaves and other plant trash or plastic sheets. Ideal mulch is one that is readily penetrated by rain, maintains its form through the season and can eventually be cultivated into the surface soil later to be replaced with further mulch.

Some of the advantages of mulching in fruit growing include the following:

* Protect he soil from rain erosion and especially from rain-splash
* Improve water infiltration
* Conserve soil moisture by preventing desiccation through surface evaporation
* Enrich the soil with nutrients when mulches are decomposed
* Encourage microorganisms living in the soil
* Improve soil structure and
* Reduce weed growth near cultivated plants

**Plastic mulch**

Plastic sheets are useful in many ways:

* Unlike plant mulches, they do not rot and, with due care, can be used again and again;
* They are labour-saving because unlike plant trash, they do not have to be chopped up and transported;
* They let plants derive even benefit from soil water for the whole cultural season, in contrast to the effects of plant mulch which vary as the season progresses; and
* Finally, plastic sheets smother weeds more effectively because they cut out the light.

As plastic sheeting tends to be expensive and is not easily obtainable, it is worthwhile using cover material such as old fertilizer sacks, cement bags, and flour bags; all are particularly hardy for tree seedlings. Even heavy-duty paper can be used. There are many kinds of plastic sheeting, of varying thickness, different colours and different structure (smooth or porous). Thickness affects the resistance of the plastic. Colour affects soil temperature: dark coloured materials get hotter in the sun and cool off quickly at night; light colours keep the covered soil at a more even temperature. Smooth, un-perforated sheets do not let rain water or evaporation through. Perforated and porous sheets let a certain amount of water through, but limit evaporation. This is true of sacks made of braided plastic fibers that are often used commercially for selling cereal grains, flours and other produce.

Two special precautions must always be taken when plastic sheets are laid on a cultivated patch or round the base of young trees:

* The round must be thoroughly moistened before fixing the sheet in place and, if necessary, abundantly watered;
* Water infiltration around the plastic cover must be encouraged by the right technique - tilling, straw cover, stone, mulch etc.

**Some tips about mulching**

* The plant waste used for mulching must not contain any seeds or vegetative propagules. The gardener must avoid spreading unwanted plants that will have to be controlled later on;
* There are two reasons why the layer of mulch must not be too thick: first it must not be allowed to absorb all the water during light rains, nor prevent air from reaching the soil. A layer between five and ten centimetres thick is usually just right;
* The layer must not be too thin because it would not give effective cover and might rot quickly;
* Mulches are only spread on soil loosened by tilling or weeding. When soil is compacted under cover, mulch does not stop runoff completely and has only a limited effect on water infiltration;
* Mulch must let rainwater filter through. Large, spreading leaves should be avoided because rainwater falling on them flows away from the cultivated plants;
* Chopping up mulching is really worthwhile because it makes the layers of waste more permeable and speeds up rotting, A straw chopper or compost crusher will do the job; and
* Direct contact between plant leaves and mulches must be avoided because fungal diseases can be transmitted in this way.

## 3.7. Fertilization

**Fertilizer application program in fruit plantations**

A suitable optimum yield of fruits depends, beside other factors such as water and solar radiation, on the availability of essential elements and the content of organic matter in the soil. If fertility status of the soil is low, the soil needs to be fertilized. In this case four important issues deserve due considerations:

**Determination of the type of fertilizer to be used-**The selection of a suitable fertilizer depends largely on the essential element level of the soil with respect to the contents of the fertilizer, the essential element requirements of the crop, and the season of the year.

**The essential-element level of the soil-**Very often, world soils vary in their capacity to supply essential elements. Thus, if the same crop is grown on different soils, though other factors are kept constant (temperature, moisture, light intensity, etc.), each soil may require different ratios of nutrients.

**The essential element requirements of the crop-**Different fruit crops grown on the same soil also differ in fertilizer requirements. In other words, the nutrient requirement of crop varies with species, and even within the same species the requirement may differ from cultivar to cultivar.

**The season of the year*-***Principal factors concerned are temperature and light. When other factors are favorable the temperature of the soil markedly influences the amount of available nitrogen. In general, if the soil has been cold for a considerable period, the natural nitrate-nitrogen supply is likely to be low and artificial applications are necessary. On the other hand if the soil has been warm for a considerable period, with other factors favourable, the natural nitrate-nitrogen supply is likely to be high.

**Determination of time of fertilizer application***-* The time of fertilizer application is determined based on the following two factors:

**The type of fertilizer to be used-**Less mobile types of fertilizers, such as DAP and organic fertilizers, are applied before planting or before active growth of plants has started, while fertilizers that contain readily soluble and available nutrients (e.g. nitrogen fertilizers), should be applied when plants are actively growing, To minimize loss of such fertilizers, application has to be in a split form so that plants can readily utilize them.

**Growthand development stage of the fruit plant***-* Fruit plants are known to have high fertilizer requirements at flowering and fruit setting stages.

**Determination of rate of fertilizer to be used-**To achieve optimum fertilizer application of fruit plants, the following factors should be considered:

**The content of plant nutrients in the soil***-* This is determined by soil and/or leaf analysis. However, nitrogen content is not analyzed because *of* high losses due to leaching or volatilization. Deficiency of some nutrients can also be visually judged based on symptoms observed on live plants in the field.

**Kind of the fruit species or cultivar***-* The essential- element requirements of different fruit species or cultivars grown on the same type of soil are known to be different. Some are light feeders (e.g., guava), while others are heavy feeders or demanding (e.g., banana).

**Age of the fruit plant-**Young plants at their juvenile stage require relatively less fertilizer as compared to mature, fully fruit bearing plants.

**Determination of method of fertilizer application***-* Fertilizers may be applied to fruit orchids or vineyards by using anyone more of the following methods: broadcasting, basal dressing, side dressing, top dressing, ring application, and foliar application.

Application of organic fertilizers such as, farm-yard manure, compost and other organic household refuses, with irrigation water is also common in some parts of the country.

## 3.8. Training and pruning of fruit plants

Training and pruning are well known but are by no means universal practices.

**Training:** involves physical techniques that control the shape, size and direction of plant growth. Training is in effect the orientation of the plant in space. It may include bending, twisting, or fastening of the plant to the supporting structure.

**Pruning:**involves the removal of parts of the top or root system of plants. Pruning of fruit plants is an integral part of the procedures used for high production of quality fruits. Three types of pruning are known: frame, maintenance and rejuvenation.

* **A framework:**is best formed in the nursery; it usually consists of a single stem split up in four main branches, each occupying a sector.
* **Maintenance pruning:**aims at the preservation of the status.
* **Rejuvenation pruning:**is meant to bring declining trees back into production.

In successful fruit production it is essential that the fruit grower knows the correct pruning procedures as well as understanding the importance of pruning.

**Some specific reasons for pruning fruit plants are to:**

**Develop a strong trunk and scaffold system of branches**:well distributed around the tree, which are able to support heavy loads of fruit without limb breakage.

**Control fruit production:**Proper pruning encourages development of the type of shoot system required to produce the fruit. In older trees with little vegetative growth rejuvenation pruning can force the development of productive fruiting shoots. Pruning can also be used to limit excess numbers of fruits (over bearing) by removing some fruit-bearing branches, giving a thinning effect that can Improve fruit and quality, In general, shoot pruning reduces the number of growing points of any given fruit plant; this increases the supply of available nitrogen and other essential elements to the remaining growing points. Pruning the top, therefore, promotes the development of cells and the utilization of carbohydrates. Accordingly, it promotes the vegetative phase and retards the reproductive phase. If, for example, orchard trees are young and vigorous, pruning, if necessary, should be very light, since heavy pruning of the top delays flower-bud formation. On the other hand, if orchard trees are old and weak, severe pruning of the top helps to promote vigor and rejuvenation.

**Limit tree size:**to the space allocated to it and to limit tree height to manageable size (i.e., fruit can be conveniently harvested). Pruning the top reduces the total vegetative growth. Numerous investigations have shown that pruning the top dwarfs the fruit tree. The total number of growing points is reduced, resulting in fewer developing shoots, fewer leaves, reduced photosynthesis, reduced amounts of carbohydrates translocated to the roots, reduced root growth, followed by a reduction in mineral and water absorption, which, in turn, decreases shoot growth. Generally, the more severe the pruning, the greater the dwarfing.

* Improve light penetration to the inner and lower parts of the tree.
* Remove dead, broken, or interfering branches.
* Facilitate insect and disease control by opening the tree, thus increasing penetration of spray materials to the interior branches and removing diseased branches.

**There are two kinds of top pruning:**

**Heading back:**consists of cutting back the terminal portion of a branch to a bud, that is, the terminal portion of twigs, canes, or shoots are removed, but the basal portion is not. This procedure forces out new shoots from buds below the cut und retards terminal growth of the branch and favours lateral growth.

**Thinning out:** is the complete removal of a branch to a lateral or main, that is, the entire twig, cane, or shoot is removed. Thinning out corrects an overly dense area or removes interfering or unneeded branches. In general, heading back stimulates the development of more growing points than a corresponding thinning out.

When branches are headed back, it should be done with a slanting cut at an angle of approximately 45°, just above a healthy bud, with the bud opposite the slant. The lower part of the slant should be above the base of the bud. The cut should be clean and sharp to encourage rapid healing. No stub should be left above the bud and the cut surface should be as small as possible. Also when thinning out branches should be cut close to the bulge on the main stem leaving no stub. Any stub left will give rise to fungal infection due to delay in healing and this may eventually affect the main stem.

## 3.9. Pollination Management

During the planting process the farmer should create the best conditions for the future pollination, which will determine the potential yield capacity of the orchard. This principle is not necessarily applied for good self-fertile cultivars, but is essential for the self-infertile and self-sterile cultivars. In these cases the potential yield capacity is determined by the distance between the fruit tree and the pollinizer male tree or cultivar.

## 3.10. Weed, Disease and Insect Management

A heavy growth of weeds utilizes soil moisture and mineral elements, particularly nitrogen, which would otherwise be better used by the fruit plants. In addition, weeds interfere with orchard or vineyard operations-pruning, fertilization, thinning, irrigation and harvesting. In dry seasons, as the weeds die, they constitute a serious fire hazard and can harbour rodents that will damage tree trunks when food is scarce. In well- managed fruit plantings, where irrigation water is scarce or expensive, weeds should be meticulously controlled.

At the early stages of field establishment weeds often cause greater losses than insects or plant diseases. A very important factor in improving growth and development, and thereby increasing the yield of fruit crops, is therefore efficient weed control.

The weed control program should be designed in such a way that a weed population is kept to a level where there is no significant competition with the fruit crop being grown. Principal methods of control include the following:

**Quarantine:**This is a system adopted to control the introduction of weeds into clean areas. Plant quarantine measures offer the best and most economical safeguard against weeds (and also other pests such as fungi, bacteria, viruses, nematodes, insects etc.) introduction.

**Clean weeding:**It reduces competition for nutrients and moisture. Clean weeding as a weed control practice is not recommendable in most cases as it leads to loss of organic matter in the soil and to erosion even on flat land. Cultivation with ploughs, discs and other implements is therefore, not advisable in fruit farming except, perhaps, just before planting.

**Inter cropping:**Growing annual crops (preferably legumes) that provide good cover and improve the soil with their root nodules is advisable. This practice enhances the competitive ability of fruit plants on weeds and reduces the chance of weed growth.

**Slashing:** Where labor costs are low, weeds can be slashed periodically with machetes or cutlasses. Some orchards are managed as a *sod culture system* in which low growing grasses cover the orchard floor. Sad culture is useful mainly for plantings on sloping hillsides where soil erosion is a problem and for areas where the water supply is plentiful and cheap enough to support both grasses and fruit trees. If rainfall is abundant, water use by the grasses is not a problem, Extra nitrogen and, perhaps potassium, must be added however to compensate for what is used by the grasses. Sad culture of course entails increased fertilizer costs, the added cost of mowing the grasses, and possibly added irrigation costs. Sod orchards, due to shading of the soil surface, are cold during bloom and are therefore subject to crop losses from frost damage.

**Chemical weed control:** Different organic and inorganic compounds are used which are toxic to weeds. These chemical products are called herbicides which may be classified into four general categories:

**Contact herbicides:** kill tissues at, or very close to, the point of application. Therefore they must be thoroughly distributed over the surface of the plant in order to kill the tissues in buds and leaves. Contact herbicides may be selective or non- selective, depending mainly on differential wetting and based on differences in cuticle, leaf arrangement, and location of buds. *Non-selective contact herbicides* kill all vegetation, to which they are applied.

**Systemic or translocated herbicides:** Enter the plant and move in the vascular tissues throughout the plant system. A translocated herbicide treatment is one in which the herbicide, after entry, is capable of moving within the plant to exert effects away from the side of application either in the above ground or in underground parts of the plant. Selectivity depends on some specific feature of the plant, usually differences in enzyme systems.

The particular herbicide within each group to be used on a particular crop at a given time depends on the nature of the weed infestation, soil type, rainfall and temperature. The close similarity between the response of the crops and that of the weeds in each group emphasizes the principle that the more closely related the crop is to the weed the more difficult it will be to find a herbicide which will give selective control.

In developing countries, like Ethiopia, where machinery and chemicals are lacking, and labouris available, weeds must be pulled by hand or destroyed with very simple roots.

Cultural practices like, use of fertilizers, time and method of planting, and correct rotation of crops also suppress the weed population.

For best results, a combination of one or more of the aforementioned weed management practices (methods) should be applied in fruit crops production to obtain the best results.

**Plant diseases management**

A plant disease is a harmful alteration of the normal physiological and biochemical processes of a plant.

Fruit crops are subject to a wide array of plant diseases. Plant diseases can be caused by infectious virulent pathogens (such as bacteria, fungi, viruses, and mycoplasma, like organisms). The majority of fruit crops are susceptible to attacks by at least one of these pathogens, whereas some of them are susceptible to many.

Bacteria that cause fruit diseases are spread in many ways- they can be splashed away by rains or moved on windblown dust, the feet of birds, or on insects. People may unwillingly spread bacterial diseases by, for instance, pruning infected orchard during the rainy season. Water facilitates the entrance of bacteria carried on pruning tools into the pruning cuts. Propagation with bacteria-infected plant material is a major way for pathogenic bacteria to be moved over great distances.

Bacterial diseases in fruits are difficult to control. Measures include using resistant species or cultivars and bacteria-free seed, eliminating sources of bacterial contamination, preventing surface wounds that permit the entrance of bacteria into the inner tissues, and propagating only bacteria-free nursery stock. Prolonged exposure to dry air, heat, and sunlight will sometimes kill bacteria in plant material. They are also killed by antibiotic treatment.

Fungal diseases of fruit crops are generally easier to control than bacterial or viral diseases. The most satisfactory method of dealing with fungus diseases is strict sanitation to eliminate the pathogenic organisms, starting with the initial stages of propagation and growth of the potential host plants.

The management measures include:

* Planting only disease free, certified seed;
* planting *only* resistant species and cultivars;
* seed treatments with fungicides;
* foliage sprays with fungicides (protectants or eradicants) e.g., downy mildew and powdery mildew of grape;
* Maintaining good soil drainage (e.g., damping off);
* Growing crops in climates unsuitable for pathogenic fungi (geographic isolation);
* Careful handling of the fruits to prevent cuts and bruises during harvest and
* storage of fruits at the proper low temperature;
* Post-harvest treatment of fruits with fungicides; and
* Biological control by means of an organism, that is antagonistic to the fungal pathogen.

Viruses are pathogenic particles that infect most fruit crops. To move from one plant to another, virus particles must have some transmitting carrier (vector). The vectors can be insects-aphids, leafhoppers, or, most commonly, thrips- or mites. The activities of humans in propagating fruit plants by budding and grafting or by cuttings is one of the chief ways of spreading viral diseases.

No chemical sprays are so far available to eradicate viruses, although insecticides can be used to control insect vectors. For orchard species, the best control measure is planting of nursery trees that have been propagated from known virus-clean sources.

Another successful way to eliminate viruses is to excise the minute shoot tip of vigorously growing plants under aseptic conditions (tissue culture), then allow the *tip to d*evelop into a new plant on a nutrient medium. The new plant will usually be free of the virus and will provide a starting point for a clone minus the virus.

**Mycoplasma like organisms-**The mycoplasma-like organisms in plants are small parasitic organisms intermediate in size between viruses and bacteria. Like viral diseases, the infective bodies in diseases caused by mycoplasma-like organisms are moved about by sucking insects such as leafhoppers, aphids, and psylla.

One obvious method of controlling the spread of these diseases is an effective spray program that eliminates the insect vectors. It has been established, too, that mycoplasma-like organisms are susceptible to certain antibiotics, particularly tetracycline, which has been used to treat pear trees with the pear decline disease (Rice et al.; 1994). Of course, this control method is known to be expensive.

**Nematodes management**

Parasitic nematodes are readily spread by any physical means that can move soil particles about, such as equipment, tools, shoes, birds, insects, dust, wind, and water. In addition, the movement of nematode-infected plants or plant parts will spread the parasites.

Various methods are available to reduce crop losses from nematodes:

* Grow only resistant species and cultivars;
* Use only nematode-free nursery stock for planting;
* Avoid importing soil (or plants with soil on their roots) from areas that could be loaded with a dangerous nematode species to a new area;
* Treat the soil area with a fumigant before planting. This method is commonly used at nursery level, as it is too expensive to use for field (permanent planting site);
* Use nematicides in certain cases. Most such materials will injure or kill plants if applied too close to their root zone. Nematicides must therefore be used carefully;
* Rotate fruit crops (commonly short-term perennials) to control certain nematodes.

**Insect management**

Insect pests may be classified according to the way they feed on plants. In general, there are two groups (Edmond, 1983): (l) those with *biting mouth* parts and; (2) those with *sucking* and/or *rasping mouth* parts.

Insects *with biting mouth parts* are classified according to the part of the plant on which they feed. They form four more or less distinct groups:

**Stem and leaf eaters** :such insects reduce the chlorophyll content of leaves. This reduces the amount of light that can be absorbed per unit time, which in turn, reduces the photosynthetic capacity of plants (the amount of initial food to be synthesized). Some of the examples include the caterpillars of certain butterflies and moths, cutworm, apple-tree tent caterpillar, grasshoppers, leaf miners etc.

**Root feeders***:*they eat the younger portions of the root system and reduce the area for the absorption of water and nutrients. This reduces the amount of water which can be absorbed per unit time, while transpiration is not reduced. The strawberry root-worm is a typical example of such a group of insects.

**Stem borers:**in general, such insects bore into the stems and eat the xylem (such as the herbaceous stem borers) or puncture/sever the secondary phloem (such as the woody stem borers). This stops the flow of water into the leaves above the damaged area,or reduces the flow of manufactured substances to the roots. Examples of woody stem borers are peach tree borer, apple tree borer, and raspberry cane borer.

**Feeders on fleshy fruits, seed, and storage organs***:*these are usually the larvae of moths and beetles. These larvae eat large quantities of food and make the fruits unfit for human consumption (e.g., larvae of fruit flies on guava).

**Insects with sucking or rasping mouth parts:** Such types of insects pierce the epidermis suck the tiny chloroplasts, soluble foods, and vitamins from the leaves (or succulent parts of the plant), and make them incapable of making chlorophyll. This reduces the amount of light which would otherwise be absorbed and the amount of initial food substances to be synthesized. Examples of insects with sucking mouth parts are the many kinds of aphids, thrips, scales and mealy bugs.

**Management measures**

The management methods for harmful insects are four types.

**Biological control systems:** Other living entities/ insects (e.g., the lady-bird beetle, adult and larvae, feed on aphids) viruses, fungi and bacteria may be introduced as parasites/predators into harmful insect populations.

**Rearing and sterilizing:** by the radiation of massive numbers of male insects. Released by the millions, the sterile males mate with wild fertile females, but produce no offspring.

**Genetic strains:** of plants resistant to insect attacks. The use of plant species or cultivar tolerant or resistant to insects attack is getting very popular as it is environmentally very friendly.

***Pesticides***: these constitute the chief weapon for protecting plants and conserving plant products. Action of pesticides used to control insects and mites include: stomach poison action, contact action, fumigation, suffocation and attractant action (pheromones) and repellent action. However, pesticides are not friendly to the non-target organisms and also may result in secondary pest outbreak.

**Vertebrates**

Rodents such as, mole rat, house mice and others are known to cause great damage or losses to fruits (both on live plants and produces). The tunnels of moles can be a real problem in fruit orchards. Roots are often seriously damaged by such pests.Young fruit trees and planted seeds in nurseries are usually damaged by mice, rabbits and other wild animals. Rabbits commonly feed on bark and completely girdle fruit trees (e.g., apple trees). Unless bridge grafting is done promptly, even large trees may be killed.

The strategy in rodent control is, first, to remove all food and water available to them from the areas they inhabitant and second to place bait traps in their way. Certain birds are a major threat to some fruit crops, such as grapes, strawberries, guavas, papayas and plums.

A non-destructive method of keeping birds from eating the fruits in vineyards or orchards are amplified recordings of birds distress callsthat are played at intervals during the day at fruit maturity and/or harvest time. In Ethiopia, traditionally birds and other vertebrate pests are kept away from eating fruits by using s*care-crows,* though the method is not as such satisfactory.Other vertebrate wildlife, such as monkeys and apes, also cause serious damage to some fruits. Alert guards are required to protect fruits from the attack of such wild.

**3.10. Harvesting and post-harvest handling**

**Harvesting** is the process of gathering mature [crops](http://en.wikipedia.org/wiki/Crops) from the [fields](http://en.wikipedia.org/wiki/Field_(agriculture)).Maturity indices important for deciding when a given commodity should be harvested to provide some marketing feasibility and to ensure the attainment of acceptable eating quality to the consumer. The decision as to the time of harvest for a given fruit must be made to provide a margin of safety for marketing and to supply the consumer with fruit good eating quality. Fruits picked at the wrong stage of maturity may develop the physiological disorders in storage and may exhibit poor dessert quality. They are also likely to be low dessert quality from the stand point of color, size and flavor. The harvest marks the end of the growing season, or the growing cycle for a particular crop. On smaller [farms](http://en.wikipedia.org/wiki/Farm)with minimal [mechanization](http://en.wikipedia.org/wiki/Mechanization), harvesting is the most [labor](http://en.wikipedia.org/wiki/Manual_labour)-intensive activity of the growing season. On large, mechanized farms, harvesting utilizes the most expensive and sophisticated [farm machinery](http://en.wikipedia.org/wiki/Farm_machinery), like the [combine harvester](http://en.wikipedia.org/wiki/Combine_harvester).

**Maturity Determination**

Determination of maturity can be grouped into physical, chemical, physiological, etc. based on the principles used for measuring the various parameters.

**Physical method**

**Skin color:** change of skin color of many fruits at maturity is very common (Papaya, banana, mango...).

During maturity or ripening fruits usually change their color from deep green to yellow, orange or red etc. Instruments are also available for measuring color of fruits and this is mostly used in harvested fruits at commercial level.

**Shape**: the shape of fruit can change during maturation. Eg.: Banana becomes less angular

**Size:** Size is frequently used to determine at harvest. It is related to market requirement.

**Firmness**: As fruits mature and ripen the tissues become soften. The softening can be estimated by the finger feel of commodity (firmness can be measured by penetrometer).

**Specific gravity**: It is measured through weight of solids or liquids. As fruits mature their specific gravity increases. This method is rarely practiced.

**Aroma**: Most fruits synthesis volatile chemicals as they ripen. Based on this we can determine whether fruit is ripe or not.

**Chemical method:**

**a) Sugar**: As the fruit ripens, starch is broken down to sugars. Measurement of sugars indicates the stage of maturity or ripeness. Sugar constitutes the major portion of soluble solids of the fruit juice. Measurement of total soluble solid (TSS) is done using refractometer.

**b) Starch**: Starch content in developing fruit of pear and apple provides harvest maturity.

**c) Acidity**: The acidity of many type of fruit changes during maturity and ripening. In citrus, mango, pineapple and many other fruits acidity progressively decrease as the fruit matures on the tree.

**Physiological methods**

Climacteric fruits, in which there is a distinct rise in respiration during ripening, can be sampled and kept at high temperature and respiration rate is measured. By this way we can predict the number of days will take for ripening stage if left on the tree.

Climacteric fruit: harvested at full maturity stage and ripen after harvest. Maximum respiration starts immediately after harvest. Eg: apple, avocado, banana, mango, papaya, peach and watermelon.

Non-climacteric fruits: Harvested at full ripening (90-95%) complete color development. Rate of respiration is less than climacteric fruit. Eg: cucumber, grapes, citrus fruit, pineapple etc.

Harvesting Methods

**By hand**

In developing countries, most produce for internal rural and urban markets is harvested by hand. Larger commercial producers may find a degree of mechanization and advantage, but the use of sophisticated harvesting machinery will be limited for the most part to agro-industrial production of cash crops for processing or export or both. In most circumstances, harvesting by hand, if done properly, will result in less damage to produce than machine-harvesting.

Hand-harvesting is usual where fruit or other produce is at various stages of maturity within the crop, that is, where there is need for repeated visits to harvest the crop over a period of time. Machine-harvesting is usually viable only when an entire crop is harvested at one time. Many ripe fruits have a natural break-point of the fruit stalk, which can easily be broken at harvest. Fruit and other seed-bearing structures harvested in the immature or unripe green state are more difficult to pick without causing damage to either the produce or the plant. These are best harvested by cutting them from the plant, using clippers, secateurs or sharp knives. The clippers may be mounted on long poles for tree fruits, with a bag attached to the pole to catch the fruit

**Mechanical**

Because the supply of fresh produce to domestic markets in developing countries comes mainly from relatively small-scale producers with limited resources, mechanical systems for "once over" crop harvesting are likely to be rare. There is scope, however, for the use of mechanical aids in modest commercial operations, especially where tractors are available.

**Pre-Cooling**

It is desirable to remove field heat of the harvested fruits, particularly when harvested during hot weather. This prevents the ripening and ageing of the produce. Prompt cooling conserves weight which gives an added advantage during the extended period of storage. Cooling reduces their respiration rate especially, climatic fruits such as banana, papaya and mango, thereby preventing over-ripening. Sometimes, stages of ripening and the level of field heat also determine the need of pre-cooling.

Pre-cooling can be accomplished by:

* Placing the produce in refrigerated trucks with forced humidified air circulation
* Placing ice in packages
* Placing ice in water and passing through a spray of cool water
* Through vacuum cooling
* Hydro-cooling, accomplished by flooding, spraying or immersing, is a rapid and affective method since water is an excellent material to transfer the heat from the produce to the cooling medium.

**Postharvest Harvest Handling**

*After harvesting* immediatepost harvest handling system is important. The three main objectives of applying postharvest technology to harvested fruits and vegetables are:

1. To maintain quality (appearance, texture, flavor and nutritive value)
2. To protect food safety, and
3. To reduce losses (both physical and in market value) between harvest and consumption.

There are many interacting steps involved in any postharvest system. Produce is often handled by many different people, cooling, sorting, cleaning, packing,transported (shipping to the wholesale or consumer market) and stored repeatedly between harvest and consumption. While particular practices and the sequence of operations will vary for each crop, there is a general series of steps in postharvest handling systems that are often followed.

* Harvesting and preparation for market
* Packinghouse operations
* Packing and packaging materials
* Decay and insect control
* Temperature and relative humidity control
* Storage of horticultural crops
* Transportation of horticultural crops
* Handling at destination

**Packing and Packaging Practices**

A variety of improved packages, including plastic crates, liners for rough containers, waxed cartons, wooden crates or rigid plastic containers and smaller sized sacks all are to be simple to use and cost effective.Improved packing practices and packaging materials that can reduce postharvest losses and improve incomes for small-scale produce farmers, handlers and marketers by increasing the quality and storage lifeof fruits.Ethylene absorber sachets placed into containers with ethylene sensitive produce can reduce the rate of ripening of fruits, de-greening of vegetables or floral wilting. Sachets can be purchased from internet based companies.

**Cooling Practices**

Throughout the period between harvest and consumption, temperature control has been found to be the most important factor in maintaining product quality. Fruits, vegetables and cut flowers are living, respiring tissues separated from their parent plant. Keeping products at their lowest safe temperature (0 °C or 32 °F for temperate crops or 10-12 °C or 50-54 °F for chilling sensitive crops) will increase storage life by lowering respiration rate, decreasing sensitivity to ethylene gas and reducing water loss. Reducing the rate of water loss slows the rate of shriveling and wilting, causes of serious postharvest losses.

Keeping products too cool can also be a serious problem. It is important to avoid chilling injury, since symptoms include failure to ripen (bananas and tomatoes), development of pits or sunken areas (oranges, melons and cucumbers), brown discoloration (avocados, cherimoyas, eggplant), increased susceptibility to decay (cucumbers and beans), and development of off-flavors (tomatoes) (Shewfelt, 1990). Cooling involves heat transfer from produce to a cooling medium such as a source of refrigeration. Heat transfer processes include conduction, convection, radiation and evaporation.

If a ready supply of electricity is available, mechanical refrigeration systems provide the most reliable source of cold. Methods include room cooling, forced-air cooling and evaporative cooling. A variety of portable forced-air coolers have been designed for use by small-scale growers and handlers. However, a variety of simple methods exist for cooling produce where electricity is unavailable or too expensive. Some examples of alternative systems include night air ventilation, radiant cooling, evaporative cooling, the use of ice and underground (root cellars, field clamps, caves) or high altitude storage.

Another aspect to consider when handling fruits and vegetables is the relative humidity of the storage environment. Loss of water from produce is often associated with a loss of quality, as visual changes such as wilting or shriveling and textural changes can take place. If using mechanical refrigeration for cooling, the larger the area of the refrigerator coils, the higher the relative humidity in the cold room will remain. It pays however, to remember that water loss may not always be undesirable, for example if produce is destined for dehydration or canning.

For fresh market produce, any method of increasing the relative humidity of the storage environment (or decreasing the vapor pressure deficit (VPD) between the commodity and its environment) will slow the rate of water loss. The best method of increasing relative humidity is to reduce temperature. Another method is to add moisture to the air around the commodity as mists, sprays, or, at last resort, by wetting the store room floor. Another way is to use vapor barriers such as waxes, polyethylene liners in boxes, coated boxes or a variety of inexpensive and recyclable packaging materials.

**Storage Practices**

If produce is to be stored, it is important to begin with a high quality product. The lot of produce must not contain damaged or diseased units, and containers must be well ventilated and strong enough to withstand stacking. In general proper storage practices include temperature control, relative humidity control, air circulation and maintenance of space between containers for adequate ventilation, and avoiding incompatible product mixes.

Commodities stored together should be capable of tolerating the same temperature, relative humidity and level of ethylene in the storage environment. High ethylene producers (such as ripe bananas, apples, cantaloupe) can stimulate physiological changes in ethylene sensitive commodities (such as lettuce, cucumbers, carrots, potatoes, sweet potatoes) leading to often undesirable color, flavor and texture changes.

Temperature management during storage can be aided by constructing square rather than rectangular buildings. Rectangular buildings have more wall area per square feet of storage space, so more heat is conducted across the walls, making them more expensive to cool. Temperature management can also be aided by shading buildings, painting storehouses white or silver to help reflect the sun's rays, or by using sprinkler systems on the roof of a building for evaporative cooling. The United Nations' Food and Agriculture Organization (FAO) recommends the use of ferrocement for the construction of storage structures in tropical regions, with thick walls to provide insulation. Facilities located at higher altitudes can be effective, since air temperature decreases as altitude increases. Increased altitude therefore can make evaporative cooling, night cooling and radiant cooling more feasible.

The air composition in the storage environment can be manipulated by increasing or decreasing the rate of ventilation (introduction of fresh air) or by using gas absorbers such as potassium permanganate or activated charcoal. Large-scale controlled or modified atmosphere storage requires complex technology and management skills; however, some simple methods are available for handling small volumes of produce.

**Marketing**

Marketing of fruits plays a key role in the post-harvest handling chain system. In fact, efficient marketing system involves all aspects from harvest to ultimate consumption. The present day marketing system involves direct marketing, cooperative marketing or marketing through commission agents.

The commission agents or middlemen dominate in the fruit marketing system and enjoy the major share of profit. The producer/grower should make a market assessment either for local market or foreign market. And also the grower should make a market promotion and advertisement to increase the demand of the products. In addition to this, the grower should organize market through cooperatives, to ensure better return.

# CHAPTER 4.THE UNFRUITFULNESS INFRUITTREES– CAUSES AND REMEDIES

## 4.1. INTRODUCTION

Unfruitfulness is a major problem in many fruit crops and their varieties result in ahuge loss to growers and make fruit cultivation less profitable. ‘Fruitfulness’ refers to the state where a plant is not only capable of flowering and bearing fruit, but also takes these fruits to maturity. The inability to do so is known as **‘unfruitfulness’** or ‘barrenness’. In spite of adequate flowering, low fruit yields in orchards have been experienced because of low initial fruit set and subsequently higher fruit-let abscission. In an orchard, all the trees do not bear fruits equally or regularly and sometimes fail to flower and bear fruit under similar conditions where another fruit tree bears heavily. This failure to fruit may be attributed to unfruitfulness. Any interference with the development of sex cells and organs leads to unfruitfulness. Thus, unfruitfulness is one of the serious problems of orcharding and its causes need to be understood properly for effective control and obtaining of an economically acceptable production level.

### 4.2. CAUSESOFUNFRUITFULNESS

Unfruitfulness can be due to lack of balance between vegetative growths and fruiting, lack of flowering and poor fruit set, which is as a result of the unfavorable environment. It can also be due to heavy cropping, leading to inhibition of fruit bud production and poor crop in the following year. Sterility also leads to unfruitfulness due to impotence, incompatibility or the abortion of embryo. Thecausesof unfruitfulness canbe broadly groupedintotwo categories:

1. Internalfactors
2. Externalfactors

## 4.1.1.Internalfactors

Some fruit species produce abundant flowers arid set little fruit. Sometimes there may not be any fruit on a tree. Pollination failure, sterility or deficiency of nutrients may be the major cause of unfruitfulness.

**The internal factors are:**

(1) Impotency, (2) Incompatibility, and (3) embryo abortion. Some other factors are related to flower structure and form.

**These are:**

**1. Dicliny or Uni-sexuality:**

The stamens and carpels lie in separate flowers. Male or female flowers borne on same or different trees.

(a) Male and female flowers on the same plants are called monoecious, e.g., walnut, pecan nut, chestnut, banana and coconut.

(b) Dioecious:

The male and female flowers are borne on two different plants. Hence, to set more fruit male flowers from male plants are placed close to female flowers on the other plant, e.g. Date palm and papaya.

Papaya has 8 types of flowers:

(1) Pure pistillate flowering plants (2) Pure staminate (3) Both staminate and perfect flowers (4) Plants with sterile pollen (Pseudo hermaphrodite) (5) Plants producing staminate and perfect flowers but neither pollen nor pistil is fertile (Sterile hermaphrodite) (6) Plants producing staminate, pistillate and perfect flowers (7) Plants with staminate and perfect flowers (8) Plant with pistillate and perfect flowers.

**2. Dichogamy:**

In many bisexual flowers the anthers and stigma mature on different times. This condition is known as dichogamy. It acts as a barrier to self-pollination hence; unfruitfulness in such plants is the result. When the gynoecium matures earlier than the anthers of the same flower the condition of the flower is protogyny.

On the other hand when the anthers mature first and discharge their pollen earlier than the stigma of the same flower, the condition is protandry. Avocado flowers are protogynous in nature and in mango stigma are receptive for two hours but pollen is available for longer period hence such a situation is termed as protandry. Coconut can be another such example.

**3. Self-sterility**:

In such flowers the pollen does not fertilize the ovule of the same flower through stigma; this leads to unfruitfulness in many fruits. This can also be termed as incompatibility. In incompatibility, both pollen and ovule are fertile but fail to unite due to some reason. The self-sterility has been found in pear, apple, plum, almond citrus and mango cultivars. Bartlett pear is self-sterile. Commercial cultivars of loquat are self- incompatible. In plum cultivars pollinizer Kala Amritsari have been recommended due to self-incompatibility.

**4. Heterostyly:**

In this condition the flowers have short styles and long filaments (stamens) and other flowers on the same tree or species have long style and short stamens/filaments. This is known as dimorphic heterostyly. Similarly there can be trim-orphic heterostyly, i.e., stamens and styles of three different lengths, example pomegranate, litchi, sapota and almond. Hence, poor fruit set may be due to heterostyly.

**C. Physiological Reasons:**

It is difficult to assign the particular reason for unfruitfulness in some of the situations.

These physiological factors are:

**1. Pollen Tube Growth:**

The rate of pollen tube growth through the style is so slow that it does not reach the ovule. It is usually so in heterostyly condition. Poor rate of pollen tube growth has been found in pear and mandarin.

**2. Poor Pollen Germination:**

Sometimes due to physiological reasons pollen does not germinate on the stigmatic surface. This situation may bring unfruitfulness.

**3. Delayed Pollination:**

Sometimes flowers abscise because of delay in pollination, for example, if kangjikalanlemon flowers are not pollinated from outside source, all flowers fall down due to self-incompatibility. Hence, to get good crop synchronizing in pollen cultivar with that of lemon cultivars should be included as pollinator.

**4. Nutrition:**

When fruit plants over-bear in one season and get depleted in nutrition, there may be no crop in the coming year. Nutrition affects the pistils and pollen productivity both. For example, plums and peaches may not produce any crop in one year after a heavy crop in the previous year. Carbohydrate deficiency has been reported for coulure or blossom abortion and flower drop in grapes. Twenty percent sucrose spray at full bloom stage improves fruit set in soft pears.

**Table.** Various causes of flower abortion in different fruit crops

|  |  |  |
| --- | --- | --- |
| **S/N** | **Fruitplant** | **Causesofabortion** |
| 1 | Apple | Defectiveembryo,defectiveovules |
| 2 | Almond | Defectiveembryosac,gynoeciumabnormality |
| 3 | Grapes | Degenerationofnucleus |
| 4 | Kiwifruits | Pollendegeneration |
| 5 | Strawberry | Lowerbudabortion,defectivepistil |
| 6 | Sourcherry | Defectiveembryo |
| 7 | Mandarin | Abnormalpistil |
| 8 | Pecannut | Defectivepistil |
| 9 | Plum | Degenerationofpistil |
| 10 | Peach | Degenerationofnucleus,embryoabortion |
| 11 | Olive | Pistilabortion |
| 12 | Litchi | Embryoabortion |

## 4.1.2. Externalfactors

The environmental conditions govern the life cycle of a fruit plant. These conditions greatly influence the flowering and fruit setting in the fruit plant. Factors like nutrition, pruning, water supply, and rootstock used, temperature, insect pests and diseases affect the fruiting in fruit trees.

**1. Climate:**

1. **Temperature:**

This is one of the most important factors, which governs the flowering, fruiting and fruit development. Temperature requirements are species specific. Variation in day and night temperature or extreme fluctuations, or continuously hot temperature adversely affects the pollination and fruit set in most of the fruits. For example, cloudy weather at full-bloom stage affect the pollination and fruit set in soft pears and plum. Poor setting in Sapota fruit is due to drying of flowers. Temperature affects the bee activity in an orchard. Bees help in the pollination and fruit setting.

1. **Rainfall:**

Rainfall is very important to maintain the underground level of water. It also helps in improving the quality of fruits particularly in peaches, patharnakh and mango. Rain at full bloom washes away the pollen, stigmatic fluid and keep the pollinizers away, hence affecting the fruit set.

1. **Winds:**

There are many fruits which get pollinated through wind (Anemophily). For these plants movement of air at the time of flowering is necessary to affect pollination. Most of the fruit plants are insect-pollinated (entomophilous). In such plants, wind hinders rather than helping in pollination.

1. **Frost/Freeze:**

It is the most important factor for deciding the fruitfulness in an orchard. Frost injury can convert a regular bearing cultivar into an irregular bearing. Even orchards may not produce any fruit for two to three years continuously due to killing of branches caused by severe frost. Even set fruits nearing maturity in Guava were spoiled by severe frost which occurred during, December 2007 and January 2008.

1. **Hail Storm:**

Hail storm has been found to be very harmful in hilly areas. Most of the apple crop was damaged by hails at fruit set. Hails kill flower buds and blossoms. There are areas which are prone to hails and freezes every year. Some areas are almost free from these hazards in the same zone.

1. **Cloudy Weather:**

Cloudy weather is more dangerous than hails. The humidity makes the conditions most favorable to spread fungal diseases. Powdery mildew in mango and Umranber usually appears in cloudy weather.

1. **Intensity of Light:**

Light also plays a major role in the fruitfulness of an orchard. Strawberry plants develop pistils only when these are exposed to specific light intensity. In overgrown litchi and mango plantations due to overlapping shade the fruit set is reduced. Closely planted kin now ’10 by 10′ or ’10 by 20′ at full growth stage bear poorly due to poor light penetration. Even fruits do not develop proper color at maturity.

2. **Disturbed Moisture in Soil:**

Soil moisture is one of the key factors to production of fruits. The excess soil moisture as well as low soil moisture conditions at the time of flowering and fruit set encourage abscission layer formation, leading flower and fruit drop. Growing cover crops or mulching the basins can overcome the low soil moisture. Flooding of the orchards at flowering time should be avoided.

**3. Nutrition:**

When balanced nutrition is not given the plant’s growth and development is affected. The practice of application of fertilizers at the time of flowering/fruit set should be avoided. The manures and fertilizers need to be applied one to two months before flowering and in split doses after fruit setting.

Imbalance in the nutrients certainly cause unfruitfulness or flower drop. Higher does of fertilizers render many kinds of fruit plants more vegetative and without flowers or produce abnormalities in the flowers. Excess of nitrogenous fertilization induces barrenness in plants.

**4. Rootstocks:**

Rootstocks affect the scion cultivars physiologically. Quince rootstock induces dwarfing in pear due to formation of inverted bottleneck, whereas D-4 produces very vigorous pear plants. Trifoliate orange and its hybrids Troyer and Carrizo produced dwarf citrus plants than on Jatti Khatti and Kharna Khatta. The grafted plants produce early crops than those raised through seeds; this way fruiting is affected by the rootstocks. Use of inter-stock reduced the juverule period by two years in ‘Leconte’ and other soft pears. Patharnakh (Pyruspyrifolia) inter-stock was better than root suckers (Pyruscalleryana).

**5. Pruning:**

The deciduous trees are judiciously pruned each year. Un-pruned grapes bear little crop with small bunches as compared to pruned vines. Un-pruned peaches bear little fruit and are prone to limb breakage. To improve fruiting, right pruning is given every year. Similarly, summer dormant ber is pruned in May-June to get more fruit. The intensity of prurning varies from cultivar to cultivar and species to species.

**6. Plant Age:**

Some fruit plants have long juvenile period than others. These plants cannot be made to bear fruit early. The Citrus medical and C. jambhiri plants bear only male flowers in the first few years. Slowly hermaphrodite flowers appear with age. Young grape vines produce less pollen than the aged vines of the same cultivar. Very healthy plants bearless flowers than semi- healthy plants. Declining plants bear profusely than healthy trees.

**7. Chilling Requirements:**

Some fruit trees need desired chilling hours requirement for spur formation and flowering. Bartlette and conference pears do not flower in plains; whereas low chilling requiring ‘Leconte’ and other pears bear heavy fruit. Apple remains vegetative for long in lower hills than higher altitudes. Southern cultivars of mango shoots get killed due to frost or low temperature in north hence no fruiting. In ‘Leconte’ pear profuse flowering is observed every year but fruit set is irregular due to change in season.

**8. Spraying at Full-bloom:**

Normally insecticide sprays at flowering time are not recommended. However, sometimes due to prolonged flowering particularly in litchi, mango and pear, it becomes necessary to control aphids, etc. Hence, insecticide is sprayed, which adversely affect the fruit set. In mango a disease ‘Jhumka’ has surfaced due to poor pollination. Fungicides normally do not affect pollination. Insecticide sprays should be avoided on full- bloom. Spray may be advanced or delayed for a week or so.

## 4.3. Remedial Measures

### 4.3.1. Balancing fruiting and vegetative growth

***Pruning and thinning:*** The main techniques for controlling the vigor of fruit- trees and increasing the irrelative fruit fullness are the use of dwarfing root stocks, compact, short-internodes scions and of trees training and pruning system which give horizontal or wide-angled branches. As such, growth retardants are also used. The influence of pruning varies with the amount, season and kind of pruning. Judicious and proper pruning is needed to improve the fruit set and fruit retention on the trees and also on the removal of dead results in loss of carbohydrates reserves along with pruned wood. Also, severe pruning promotes too much vegetative growth and hence reduce the productivity.

### 4.3.2. Control of pollination

**Use of pollinizers:-** Pollen transfer may present an application problem in fruits which are self-incompatible. Many apple varieties are at least partially self-fertile, especially under warm weather, butin most cases, fruit-sets are improved by the use of pollinator varieties and bees. It is advisable to have a number of pollinizer varieties with widespread flowering dates to ensure cross-pollination. One of the basic requirements for setting fruit is an adequate requirement of compatible pollen. With most tree fruit crops, the need for crosspollination is recognized. Pollinating insects are necessary for fruit set on all cultivars, and most cultivars will benefit from cross- pollination. Under general conditions, the closer a tree is to apollinizer, the better fruit set will be. Cross pollination necessitates the availability of sufficient quantity of compatible pollen, a spollinizer cultivars flower synchronously the main cultivar and suitable agent for the successful and effective transfer of pollen. Therefore, suitable pollinizer cultivars must be inter planted at the time of orchard layout.

**Introduction of pollinators:** The population of natural pollinators has gone down due to indiscriminate use of pesticides and deterioration of the ecosystem. The managed bee pollination is very limited and the available bee hives, during bloom, hardy meet 2 to3% of the demand. In spadonapear, introducing the colonies sequentially (sequential introduction means introducing half of the number of the recommended number of colonies at10% FB and half at full bloom) increases the number of bee sper tree and their mobility among the rows, and consequently, it increases fruit set and yield by 50-80%. There was significant increase in fruit set in the apple orchard where bee colonies were kept for pollination and increase in fruit was significantly higher in orchard with sufficient pollinizer (>15%) than in orchards having insufficient pollinizers (<15%)(Sharma etal.,2004).

### 4.3.3. Control of frost damage

1. In early stages, a temperature of about-15°C kills 50% of the bud, but at full bloom, the temperature of-3 to-4°C can have similar effect.
2. This is due to increasing water content and decrease in their ability to super cool.
3. Exposure to low temperature and dry conditions prior to the incidence of frost induces a degree of hardening and resistance to frost.
4. Reduced by delaying bud break and blossoming.
5. Repeated sprays of paclobutrazol at 250 gmg l-1delayed flower initiation by about 13 days in pear cvs ‘Doyenne du Comice’ and ‘Conference’ (Dheimand Browning, 1988). Ethephon delays bloom up to 16 days when applied at10% leaf drop stage, but only up to 7 days when applied at 50% leaf drop stage in Italian prune tree. After frost (-2), during full bloom, damaged flowers were observed on control trees. Trees treated with ethephone escaped frost damage since they bloom 5 to 13 days later. As such, the higher yield was probably a result of avoiding frost (Crisosto,1990).

### 4.3.4. Propernutrition

Balanced supply of nutrients is always desirable for realizing optimum fruit production. Generally, it is advocated that for application of fertilizers, a few days before emergence of blossoms is generally believed to favour flowering and fruit set. Nitrogen application after terminal bud formation led to the development of flower with enhanced embryo sac longevity.

### 4.3.5. Application of plantgrowthregulators

The unfruitful behavior of several fruit plants can be overcome by the use of plant growth regulators which may be due to decreased fruit set and abscission at various developmental stages.

### 4.3.6. Use of suitable root stocks

There can be as much as 50% or more difference in the yield of a given cultivar grown on different rootstocks. The reasons for such an effect can be traced to difference in tolerance to adverse soils, in resistance to pests or in uptake of nutrients. Four roots tocks namely: M9, M7, M4 and M1 induced 50% or more bloom in the fifth year in Starking delicious apple and resulted in higher yield efficiency by controlling tree size.

# CHAPTER FIVE: MANGO FRUIT PRODUCTION AND MANAGEMENT

## 5.1. Origin and Distribution

The cultivated mango is probably a natural hybrid between M. indica and M. sylvatica that occurred in southeastern Asia to India. Selection of wild types has occurred for 4000-6000 yr, and vegetative propagation for at least 400 yr in India.

Despite the small scale of the Florida industry, it has been extremely valuable to mango cultivation worldwide due to the research and cultivar development carried out through the 1900s.

## 5.2. Composition and Use

Mangos are one of the finest fresh fruits in the world, but can be dried, pickled, or cooked as well. Mangos are higher in vitamin C than citrus fruits. Green mangos are the tropical equivalent of green apples - tart, crisp, and somewhat dry, often eaten with salt. They are cooked or used in salads in the tropics. About 25% of mangos are processed into juices, chutneys, sauces, or dried. The large seed can be processed into flour, and the fat it contains can be extracted and substituted for cocoa butter.

## 5.3. Botany and Morphology

The Mango, *Mangiferaindica*L., is the most economically important fruit crop in the Anacardiaceae family. Other important members of this family include cashew, pistachio, and the mombins (Spondias spp.).

The family contains 73 genera and about 600-700 species, distinguished by their resinous bark and caustic oils in leaves, barks and fruits.

Mango is a large, long-lived tree with a broad, rounded canopy, generally 6-30m tall. Cultivated orchards are kept at  6-10m. Leaves are lanceolate to linear, (4-16" long × 1-2" wide), dark green, with prominent light colored veins and entire margins. Emerging leaves on new growth flushes are bronze-red initially, and appear wilted. One or two growth flushes occur per year, with flushes placed sporadically across the canopy of a given tree.  Leaves may persist several years.

**Flowers:-**Tiny (1/8-1/4"), red-yellow flowers are borne in large, terminal panicles of up to 4000 individuals. About 25-98% of the flowers are male, depending on cultivar, and the remaining hermaphroditic. Panicles are initiated in terminal buds 1-3 months prior to flowering, triggered by low temperatures or seasonally dry conditions. Mango flowers are produced terminally in panicles. Individual flowers are tiny, yellow, and mostly staminate

## 5.4. Cultivar

There are two classes of cultivars: **Indochinese** and **West Indian**. The Indochinese group is characterized by flattened, kidney-shaped, somewhat elongated fruit with light green or yellow skin, and little or no red blush color. West Indian cultivars are more rounded and plump, and generally have a bright red blush to the skin. Many of the so-called "Florida cultivars" are West Indian types selected or bred in Florida, such as 'Haden', 'Tommy Atkins', 'Kent', and 'Keitt'. These cultivars including apple mango are under production and promotion in commercial and research farms of Ethiopia.

## 5.5. Ecological Requirements

**Climate** - seasonally wet/dry climate zones of the lowland tropics, or frost-free subtropical areas; ceases growth at temperatures below 55-60oF (not truly dormant). Leaves and fruit are injured by mild frost (28-32oF).**Soils** - adequately drained and mildly acidic (pH 6-7).

## 5.6. Pollination

Mangos are considered self-fertile and do not require pollinizers, but research indicates that some cultivars are self-unfruitful or at least benefit from cross-pollination. Fruit set is generally just a few percent, with an average of only one mango borne per panicle. Pollination is achieved by wild insects, and to a lesser extent, honey bees.

## 5.7. Cultural Practice/Crop Husbandry

**Propagation: -**Indochinese cultivars are often polyembryonic, and will produce true to type trees from seed. In less-developed countries, seedling trees are grown, which come into bearing later than grafted trees. West Indian mangos tend to be monoembryonic, and are mostly grafted on seedling rootstocks. Techniques vary from   inarching and approach grafting in India, to or veneer-grafting and chip budding in Florida and the American tropics.

**Rootstocks: -**Vigorous mango seedlings of various cultivars are used as rootstocks. Polyembryonic cultivars are often preferred since the rootstocks are genetically identical when grown from seed.

**Planting Design, Training, Pruning**

***Planting Design*** - square or rectangular planting system at spacing of 7—12m apart, yielding 70-200 trees/ha. Trees in alternate rows can be removed from higher density plantings once crowding occurs.

***Pruning and Training*** - very little necessary; in formative years, trees may be pruned to have one main trunk clear of branching up to about 1m. After that, they assume a desirable rounded canopy shape naturally. Later, trees may be hedged and topped to control size.

## 5.8. Harvesting and Postharvest Handling

**Maturity: -**Color change from green to yellow and the development of "shoulders" on the stem end of the fruit are the best indicators of maturity. Also, the fruit flesh turns from white to yellow starting at the endocarp and progressing outward to the skin during maturation.

**Harvest Method: -** Mangos are hand-harvested, simply by snapping-off fruits from peduncles in less-developed plantings, or by clipping peduncles 4 inches above the fruit when intended for export. This allows the milky, toxic latex to ooze from the stem without touching the fruit surface.

**Postharvest Handling: - Stems** are trimmed to 1/4" prior to packing in 14 lb boxes containing 8-20 fruits, depending on size. Fruit are culled by hand, removing diseased and off-grade fruit. In countries where fruit flies are endemic, fruit are dipped in hot water for fruit fly quarantine requirements, and anthracnose control. Fruit are stored for 15 days at 70 F and RH of 85-90% for curing postharvest.

**Storage: -** Mangos are subject to chilling injury, and must not be stored at <55°F. Storage life is only 2 – 3 weeks under optimal conditions.

**5.9.Pests of Mango**

# CHAPTER 6. BANANA FRUIT PRODUCTION AND MANAGEMENT

## 6.1. Originand Distribution

Edible Musa spp. originated in southeastern Asia, from India east and south to northern Australia. Early Filipinos probably spread the banana eastward to the pacific islands, including Hawaii, prior to recorded history. Westward, banana likely followed the major trade routes that transported other fruits, and it is known to have arrived in east Africa around 500 AD. Plants were taken from West Africa to the Canary Islands and South America in the 16th century, and spread throughout the Caribbean with settlement of the area in the 16th-17th centuries. Bananas are now grown pan-tropically in more countries than any other fruit crop in the world.

## 6.2. Composition and Use

Other than fresh consumption, bananas & plantains are used in numerous ways. Banana puree is made into baby food and ice cream, as well as baked desserts. Flour can be derived from dried fruits, and used for pastries or mixed with other flours. Dried fruit of both banana and plantain are commonly made into chips by frying slices in oil and salting. Larger slices are deep fried and eaten like french fries in many countries.  As with most fruits, the fermented juices are made into beer and wine, commonly in Africa. The young leaves and terminal inflorescence buds are edible.

## 6.3. Botany and Morphology

Bananas and plantains belong to the Musaceae, known simply as the banana family. There are 25-80 species in the genus Musa, depending on the taxonomist. Musa is important not only for fruit production, but the genus has provided man with food, clothing, tools, and shelter prior to recorded history. The naming of banana and plantain, and the distinction between the two types are mired with confusion. All banana and plantain cultivars were derived from two main species: Musa acuminataand Musa balbisiana.

Hybrids of M. acuminata and M. balbisiana are sometimes given the names Musa X paradisiacaL., Musa X sapientum L., or perhaps most accurately, M. acuminata X M. balbisianaColla. However, a shorthand method of distinguishing hybrids and accurately representing their parentage was developed in the 1950s, and is commonplace today. Each type is given a 2 to 4 letter designation consisting of A's representing acuminata, and B's, representing balbisiana. For example, AA represents a diploid type derived only from M. acuminata, and AAB represents a triploid type with 2/3 M. acuminata and 1/3 M. balbisiana parentage. In general, the most important banana cultivars in the world are AAA, and plantains are mostly AAB, ABB, or BBB.

**Plant:-** Both banana and plantain are large, herbaceous monocots, reaching 7m in some cultivars, but generally 2-4.5m tall in cultivation. Plantains are often larger than bananas. The "trunk" or pseudostem is not a true stem, but only the clustered, cylindrical aggregation of leaf stalk bases. Leaves are among the largest of all plants, becoming up to 2.75m long and 0.5m wide. Margins are entire and venation is pinnate; leaves tear along the veins in windy conditions, giving a feathered or tattered look. There are 5-15 leaves on each plant, with 10 considered the minimum for properly maturing a bunch of fruit. The perennial portion of the plant is the rhizome, which may weigh several pounds. It is often called a corm. It produces suckers, or vegetative shoots, which are thinned to 2 per plant - one "parent" sucker for fruiting and one "follower" to take the place of the parent after it fruits and dies back. It also produces roots and serves as a storage organ for the plant.

**Flowers: -**The inflorescence is a spike. Initially, it appears above the last leaves in an upright position, and consists only of a large, purple, tapered bud. As the bud opens, the narrow, white, tubular, toothed flowers are revealed, clustered in whorled double rows along the stalk, each cluster covered by a thick, purple, bract. The flower stalk begins to droop down under its own weight after opening; the flowers are negatively geotropic, and turn upright during growth.

**Fruit: -**An epigynous berry, fruit are borne in "hands" of up to 20 fruit, with 5-20 hands per spike. Fruit reach harvest maturity in 90-120 days after flower opening. The terminal bud on the stalk may be removed if fruit set is high, to allow more complete filling of fruits (sort of like thinning) since this organ continues to grow throughout fruit development.

## 6.4. Cultivar

Major cultivars of banana include 'GrosMichel' , 'Mons Mari', 'Williams', 'Williams Hybrid', and 'Grand Nain'  the most popular one in the USA.Plantain - cultivars include ‘French', ‘Horn', ‘Bluggoe' , 'Pelipita' , and 'Saba'.

In Ethiopia Dwarf Cavendish, Giant Cavendish, William I, William II, Grand Nain, Poyo, ducassi hybrid and butuzwa are the most popular dessert banana types.

## Ecological Requirements

Deep, well-drained alluvial soils are best, but bananas and plantains can tolerate a wide variety of soil conditions. Both banana and plantain are adapted to hot, wet, tropical lowlands.  Mean annual temperatures are 80 F, with minimum and maximum daily temperatures of 72-90°F. Growth ceases when temperatures drop below about 56°F, and temperatures below 50 F can cause chilling injury to fruits. Plants require about 4 inches (100mm) of rain/month, with dry seasons no longer than 3 months.

## 6.6. Pollination

Bananas are male sterile, and those of the Cavendish group are female sterile as well; fruit is set parthenocarpically.parthenocarpy is production of fruits without fertilization.

## 6.7. Cultural Practice/Crop Husbandry

**Propagation**: - Banana could be propagated using sucker or Rhizomes or pieces of rhizomes called "bits" or "eyes" (analogous to planting potatoes) or tissue cultured plantlets

**Planting Design, Training, Pruning**

**Planting Density**: Depending on class of cultivars, dwarf types 2.5m x 2.5m while giant ypes requires spacing of 3m x 3m or more.

**Banana Sucker Management**: Assignment

**Training and pruning** - Proppingis performed most cultivars with heavy fruit stalks. Removal of old leaves. Chopping the harvested pseudostem and supplement to soil as mulch is common practices throughout the cropping season.

## 6.8. Harvesting and Postharvest Handling

**Maturity: -**Fruits can be harvested when about 75% mature; occurs at 75-80 days after opening of the first hand. Harvest may be delayed up to 100-110 days after opening of the first hand.  
**Harvest Method: -**Entire bunches are cut from pseudostems by hand, and carried on the shoulder or back to a nearby tram line for longer distance transport. The cutter leaves a portion of bare stalk as a handle for transporting to the packing house.

**Postharvest Handling:** -Banana bunches are hung on tramways and pulled out of plantings by tractors or people. Hands are cut into units of 4-10 fingers, graded for both length and width, and carefully placed in poly-lined boxes. Fruit are transported when green, and ripened by exposure to ethylene gas (1000 ppm for 24 hr) at their destination, in sealed "banana ripening rooms".

**6.9. Pest of Banana**

# CHAPTER 7. PAPAYA FRUIT PRODUCTION AND MANAGEMENT

## 7.1.Origin and Distribution

Papaya is native to tropical America, from Southern Mexico through the Andes of South America. It was spread to the south by Indians, and throughout the Caribbean with Spanish exploration. The Spanish also carried it to Europe and the Pacific Islands. By the mid 17th century, papaya was distributed pan tropically. However, the disease that threatened papaya was overcome by biotechnologists at the University of Hawaii, who inserted a gene into the 'Sunrise' cultivar that conferred resistance to the virus. This made the papaya the first genetically modified fruit crop used for human consumption. Since 1998, most of the papaya acreage in Hawaii has been changed to genetically modified cultivars.

## 7.2.Composition and Use

Papaya grown is utilized largely for fresh market, with small amounts processed into juices and other processed foods. Young leaves can be cooked and eaten as a green vegetable. Green or unripe papaya is used as a vegetable or salad garnish as well, but must be boiled first to denature the papain in the latex.

## 7.3.Botany and Morphology

Papaya belongs to a small family of only 4 genera and 27-30 species, the Caricaceae (some estimate up to 71 species). A large, single-stemmed herbaceous perennial, to 9m, <6m in cultivation. Leaves are very large (up to 2 ½ ft wide), palmately lobed or deeply incised, with entire margins, and petioles of 1-3.5 ft in length. Stems appear as a trunk, are hollow, light green to tan brown, up to 8" in diameter, and bear prominent leaf scars.

**Flowers: -**Plants are dioecious or hermaphroditic, with cultivars producing only female or bisexual (hermaphroditic) flowers preferred in cultivation. Papayas are sometimes said to be "trioecious" meaning that separate plants bear either male, female, or bisexual flowers. Female and bisexual flowers are waxy, ivory white, and borne on short peduncles in leaf axils along the main stem. Flowers are solitary or small cymes of 3 individuals. Ovary position is superior. Prior to opening, bisexual flowers are tubular and female flowers are pear shaped. Since bisexual plants produce the most desirable fruit and are self-pollinating, they are preferred over female or male plants. A male papaya is distinguished by the smaller flowers borne on long stalks.Female flowers of papaya are pear shaped when unopened, and distinguished from bisexual flowers which are cylindrical.

**Fruit:-**Large, oval to round berries; sometimes called pepo-like berries since they resemble melons by having a central seed cavity. Fruit are borne axillary on the main stem, usually singly but sometimes in small clusters. Fruits are green until ripe, turning yellow or red-orange. Flesh is yellow-orange to salmon at maturity, the edible portion surrounding the large, central seed cavity in the center. Individual fruits mature in 5-9 months, depending on cultivar and temperature. Plants begin bearing in 6-12 months.

## 7.4.Cultivar

Active breeding programs in a number of countries have produced cultivars that match local preferences for fruit size, shape, flesh color, flavor, and other characteristics. 'Hortus Gold' and 'Honey Gold' are gold-yellow skinned, yellow fleshed cultivars popular in South Africa; they are twice the size of 'Solo' types grown in Hawaii, but smaller than most papaya grown in tropical America. Cultivars grown in Central America are larger, often cylindrical in shape, such as 'Cartagena', 'Cedro', and 'Santa Cruz Giant'. The transgenic cultivars 'Sunup' (red flesh) and 'Rainbow' (yellow flesh) have resistance to papaya ringspot virus, and were derived from 'Solo' parent lines.

## 7.5.Ecological Requirements

**Soils** - wide range of well-drained soils with pH 5.5-7.0; poor drainage predisposes plants to soil borne diseases; must be provided irrigation in dry seasons  
**Climate** - hot, rainy, tropical lowlands, temperatures 70-90°F;  intolerant of freezing; high wind also causes damage by fruit loss, leaf damage or uprooting

## 7.6. Pollination

Bisexual flowered plants are self-pollinating, but female plants must be cross pollinated by either bisexual or male plants.

## 7.7. Cultural Practice/Crop Husbandry

**Planting Design** - rows about 2 to 2.5m apart, yielding plant densities of 1600 -2500plants/ha.  
**Training** - no training required and little or no pruning.

## 7.8. Harvesting andPostharvest Handling

**Maturity:-**Papayas are harvested when the first hint of yellow coloration appears.  
**Harvest Method:-**Fruits are hand harvested carefully to avoid scratching the skin, which would release latex and stain the skin.

**Postharvest Handling: -**To reduce post-harvest fruit rot, papayas are commonly heat treated postharvest (110-120°F), then rinsed in cool water. Fungicides also may be used, generally in the wax applied during packing. Radiation treatments such as "Sure Beam" are used to sterilize fruit fly eggs and larva in fruit intended for export. Fruit are packed into single-layer boxes, often with tissue or foam padding to avoid bruising. Fruits can be cured at 850F and 100% humidity for better color expression prior to shipping.  
**Storage:-**Below 50°F, papayas experience chilling injury. Papayas are extremely perishable; shelf life at room temperature ranges from 3 to 8 days, depending on storage atmosphere.

**7.9.Pests of Papaya**

# CHAPTER 8:PineappleFruit Production and Management

## 8.1.Origin and Distribution

**Pineapple** (Ananascomosus) is the common name for an edible [tropical](http://en.wikipedia.org/wiki/Tropical)[plant](http://en.wikipedia.org/wiki/Plant) and also its [fruit](http://en.wikipedia.org/wiki/Fruit). It is native to [Paraguay](http://en.wikipedia.org/wiki/Paraguay) and the southern part of [Brazil](http://en.wikipedia.org/wiki/Brazil). The word pineapple in English was first recorded in 1398, when it was originally used to describe the reproductive organs of conifer trees (now termed [pine](http://en.wikipedia.org/wiki/Pine)[cones](http://en.wikipedia.org/wiki/Conifer_cone)). When European explorers discovered this tropical fruit, they called them pineapples (term first recorded in that sense in 1664) because of their resemblance to what is now known as the pine cone. The term pine cone was first recorded in 1694 and was used to replace the original meaning of pineapple.

In the scientific binomial Ananascomosus, ananas, the original name of the fruit, comes from the [Tupi](http://en.wikipedia.org/wiki/Tupian_languages) (Rio de Janeiro, Brazil) word for pine nanas, as recorded by André Thevenet in 1555 and comosus means "tufted" and refers to the stem of the fruit. Other members of the [Ananas](http://en.wikipedia.org/wiki/Ananas)[genus](http://en.wikipedia.org/wiki/Genus) are often called pine as well.

## 8.2. Composition and Use

Pineapple is eaten fresh or canned and is available as a juice or in juice combinations. It is used in desserts, salads, as a complement to meat dishes and in fruit cocktail. While sweet, it is known for its high acid content (perhaps malic and/or citric). Pineapples are the only bromeliad fruit in widespread cultivation. It is one of the most commercially important plants which carry out [CAM photosynthesis](http://en.wikipedia.org/wiki/Crassulacean_acid_metabolism).

## 8.3. Botany and Morphology

The plant is a short herbaceous perennial with 30-80 trough-shaped and pointed leaves 30–100 cm long, surrounding a thick stem. This shape of the plant has to drive water onto the stem. This water might be absorbed by axil. The early[inflorescences](http://en.wikipedia.org/wiki/inflorescence) has about 100-200 flowers. Flowers are spirally placed and each is supported by bracts. Each flower consists of 3 calyxes, 3 bluish corollas, 6 fillaments and a carpel with tree parts of stigma. Inflorescense goes to bloom about 3 weeks and it blooms from down to up. Pineapples are auto sterile and fruits are developed parthenocarpy. From these inflorescences aggregate fruits are developed. They weights from 0.3-4 kg. If the plantflowers hit pollens, seeds may develop.

## 8.4. Cultivar

Smooth Cayenne is a major processing variety that is also found fresh. Its lack of spines on the leaves is advantageous for a container plant that must be moved indoors during cold weather. Fruit of Smooth Cayenne will weigh up to 2.72 kg under good culture. Smooth Cayenne cultivar is recommended and widely under production in Ethiopia.

Red Spanish is a major fresh market pineapple that is a little harder than the others. Its fruit will weigh up to 1.81 kg and its leaves are spiny.

There are varieties of pineapple with much better eating quality than Smooth Cayenne or Red Spanish. However, those with better eating quality do not ship very well, so they are not likely to be encountered in local markets. Among the better pineapples, however, are Natal Queen, weighing 2 to 3 pounds; Pernambuco (Eleuthera), weighing 2 to 4 pounds and Abakka, weighing 3 to 6 pounds. All three of these have spiny leaves.

## 8.5. Ecological Requirements

The pineapple use to grow in continental tropical mountains up to 2500 m above sea level. It needs short period of draft during the ripening. The average temperature varies from 25-30oC during the day and 15-17oC during the night. Especially the night average temperature influences the collective blooming, which is later on important for mechanical or semi mechanical harvest. Root system not dense, that’s why it needs fertile drain leaky soils,the optimal pH is 5.5-6.2.Pineapple grows best under uniformly warm temperatures year-round. While plants might survive 28 oC, significant leaf damage would severely weaken the plant. Pineapple plants absolutely require soils with good internal drainage because they grow and fruit best in soils which are mildly acidic. Pineapples can be problematic in the moderately alkaline soils. Given the small size of the plant, it is sensitive to frost and it prefers well-drained, acidic soils.

## 8.6.Pollination

The natural (or most common) [pollinator](http://en.wikipedia.org/wiki/Pollinator) of the pineapple is the [hummingbird](http://en.wikipedia.org/wiki/Hummingbird). Pollination is required for seed formation; the presence of seeds negatively affects the quality of the fruit. In [Hawaii](http://en.wikipedia.org/wiki/Hawaii), where pineapple is cultivated on an agricultural scale, importation of hummingbirds is prohibited for this reason.

Unlike many fruit plants, pineapple is very well adapted to container culture and everything you need to get started the fresh pineapples in the local supermarket.

## 8.7. Cultural Practice/Crop Husbandry

**Propagation**

There are four kinds of propagation material on pineapple plants:

* Ratoon suckers that arise below ground
* Suckers originate in the leaf axils
* Slips grow from the fruit itself and
* Slips that grow along the stalk below the fruit (and crowns are the leafy tops of the fruit)

All four types work, although slips and suckers are preferred in commerce. Fortunately, each pineapple fruit in the supermarket comes with a crown which can be used to start the plant which will develop slips and suckers for subsequent use.

Propagules should be cut from the mother plant and set aside for a week or two week to cure. In the case of crowns, any adhering flesh should be cut away.

**Care during planting: -**For initial planting, one-gallon pots are more than adequate, with transfer to a larger container as the need arises. After curing, the lowest leaves should be pulled off so that the base of the propagule can be planted deeply enough that it won't topple over. Water thoroughly at planting and then lightly a couple of times a week. For best results, the plant should be in full sun and best establishment will occur during the warmer months of the year.

Once the propagule begins to put out new leaves, a complete, soluble fertilizer should be applied monthly, according to directions which come with the fertilizer. General houseplant fertilizer is sufficient. Because the propagule will require several months to develop its root system, the water and the soluble fertilizer should be poured or sprayed over the plant so that some of it will collect in the leaf axils. After about six months, however, the fertilizer solution should be poured into the soil and not over the plant as the latter can result in damage to the developing bud.

**Fruiting**

The time from planting to fruiting is dependent upon temperature, source and size of propagation material. For example, plantings in early spring will fruit in less time than those planted in early fall. Moreover, suckers require less time than slips which require less time than crowns. While part of this difference is because of differences in the propagation material, a major difference is in the size of the propagule, as larger propagation material generally becomes established more readily, which reduces the time to fruiting. It is expect to wait 21 to 34 months from planting to enjoy your own home-grown pineapple.

Flowering will last about two weeks, as the basal flowers on the small cone like fruit open first. At flowering, a support stake and loose ties should be installed to prevent the young fruit from being knocked over accidentally.

Fruit quality is best when the fruit is allowed to develop its yellowish orange rind color on the plant, as there is no improvement in quality after the pineapple is harvested. Obviously, those in the supermarket had to be harvested before they had achieved the best eating quality, just like tomatoes, peaches and some other produce.

**Forcing:-** Pineapple can be "forced" to flower in order to produce fruit sooner than it would under natural conditions. If the plant is large and vigorous, the fruit produced will be about as large as if it had flowered normally; otherwise, fruit size and quality will be reduced by forcing.

**Ratooning:-** If the pineapple mother plant is large and healthy, and if you leave one or two suckers on it while the fruit is developing, additional fruit will form and be ready for harvest about a year after the initial fruit. With good care, most will continue to produce additional fruit every year for several years. If the ratoon fruit is significantly smaller than the original fruit, it is probably best to start over with new suckers taken from the mother plant.

## 8.8. Harvesting and Postharvest Handling

**Time of maturity: -**If you don't have the patience to wait two to three years for a pineapple, but would like to grow a miniature pineapple fruit as a novelty, it can be done in about six to eight months. Using one-gallon containers and crowns (or other propagules), grow as previously described until good rooting has occurred, usually in about two or three months. Then force flowering as previously described in four months, more or less, from forcing, you should have a miniature pineapple plant complete with a miniature pineapple. This fruit is edible, but only barely so, as it is of very poor quality and contains very little flesh relative to the core and rind.

**Storage and transport**:- Fresh pineapple is often somewhat expensive as the tropical fruit is delicate and difficult to ship. Pineapples can ripen after harvest, but require certain temperatures for this process to occur. Like [**bananas**](http://en.wikipedia.org/wiki/Banana), they are chill-sensitive and should not be stored in the refrigerator. They will, however, ripen if left outside of a refrigerator. The ripening of pineapples can be rather difficult as they will not ripen for some time and in a day or two day become over-ripe, therefore, pineapples are most widely available canned.

## 8.9. Pests of Pineapple

Pineapples are subject to a variety of diseases, the most serious of which is wilt disease vectored by [mealybugs](http://en.wikipedia.org/wiki/Mealybug). The mealy bugs are generally found on the surface of pineapples, but can also be found inside the closed blossom cups. Other diseases include pink disease, bacterial [heart rot](http://en.wikipedia.org/wiki/Heart_rot), and [anthracnose](http://en.wikipedia.org/wiki/Anthracnose).

**CHAPTER 9.GUAVA FRUIT PRODUCTION AND MANAGEMENT**

## Origin and Distribution

The guava has been cultivated and distributed by man, by birds, and sundry 4-footed animals for so long that its place of origin is uncertain, but it is believed to be an area extending from southern Mexico into or through Central America. It is common throughout all warm areas of tropical.

## Composition and Use

Raw guavas are eaten out of hand, but are preferred seeded and served sliced as dessert or in salads. More commonly, the fruit is cooked and cooking eliminates the strong odor. A standard dessert throughout Latin America and the Spanish speaking islands of the West Indies is stewed guava shells (*cascos de guayaba*), that is, guava halves with the central seed pulp removed, strained and added to the shells while cooking to enrich the syrup. The canned product is widely sold and the shells can also be quick-frozen. They are often served with cream cheese. Sometimes guavas are canned whole or cut in half without seed removal.

Green mature guavas can be utilized as a source of pectin, yielding somewhat more and higher quality pectin than ripe fruits.Ascorbic acid–mainly in the skin, secondly in the firm flesh, and little in the central pulp–varies from 56 to 600 mg. It may range up to 350-450 mg in nearly ripe fruit. When specimens of the same lot of fruits are fully ripe and soft, it may decline to 50-100 mg. Canning or other heat processing destroys about 50% of the ascorbic acid. Guava seeds contain 14% of aromatic oil, 15% protein and 13% starch. The strong odor of the fruit is attributed to carbonyl compounds.

**Other Uses**

**Wood:** The wood is yellow to reddish, fine-grained, compact, moderately strong, weighs 650-750 kg per cubic meter; is durable indoors; used in carpentry and turnery. It is good fuel wood and also a source of charcoal.

**Leaves and bark:** The leaves and bark are rich in tannin (10% in the leaves on a dry weight basis, 11-30% in the bark). The bark is used in Central America for tanning hides. Malayans use the leaves with other plant materials to make a black dye for silk.

**Wood flowers:** In Mexico, the tree may be parasitized by the mistletoe, *Psittacanthuscalyculatus* Don, producing the rosette-like malformations called "wood flowers" which are sold as ornamental curiosities.

**Medicinal Uses:** The roots, bark, leaves and immature fruits, because of their astringency, are commonly employed to halt gastroenteritis, diarrhea and dysentery, throughout the tropics. Crushed leaves are applied on wounds, ulcers and rheumatic places, and leaves are chewed to relieve toothache. The leaf decoction is taken as a remedy for coughs, throat and chest ailments, gargled to relieve oral ulcers and inflamed gums; and also taken as an emmenagogue and vermifuge, and treatment for leucorrhea. It has been effective in halting vomiting and diarrhea in cholera patients. It is also applied on skin diseases. A decoction of the new shoots is taken as a febrifuge. The leaf infusion is prescribed in India in cerebral ailments, nephritis and cachexia. An extract is given in epilepsy and chorea and a tincture is rubbed on the spine of children in convulsions. A combined decoction of leaves and bark is given to expel the placenta after childbirth.

The leaves, in addition to tannin, possess essential oil containing the sesquiterpene hydrocarbons caryophyllene, bisabolene, aromadendrene, selinene, nerolidiol, caryophyllene oxide and also some triterpenoids and sitosterol. The bark contains tannin, crystals of calcium oxalate, ellagic acid and starch. The young fruits are rich in tannin.

## Botany and Morphology

One of the most gregarious of fruit trees, the guava, *Psidiumguajava* L., of the myrtle family (Myrtaceae. A small tree to 33 ft high, with spreading branches, the guava is easy to recognize because of its smooth, thin, copper-colored bark that flakes off, showing the greenish layer beneath; and also because of the attractive, "bony" aspect of its trunk which may in time attain a diameter of 25 cm. Young twigs are quadrangular and downy. The leaves, aromatic when crushed, are evergreen, opposite, short-petioled, oval or oblong-elliptic, somewhat irregular in outline; 7-15 cm long, 3-5 cm wide, leathery, with conspicuous parallel veins, and more or less downy on the underside. Faintly fragrant, the white flowers, borne singly or in small clusters in the leaf axils, are 2.5 cm wide, with 4 or 5 white petals which are quickly shed, and a prominent tuft of perhaps 250 white stamens tipped with pale-yellow anthers.

The fruit, exuding a strong, sweet, musky odor when ripe, may be round, ovoid, or pear-shaped, 5-10 cm long, with 4 or 5 protruding floral remnants (sepals) at the apex; and thin, light-yellow skin, frequently blushed with pink. Next to the skin is a layer of somewhat granular flesh, 3-12.5 mm thick, white, yellowish, light- or dark-pink, or near-red, juicy, acid, subacid, or sweet and flavorful. The central pulp, concolorous or slightly darker in tone, is juicy and normally filled with very hard, yellowish seeds, though some rare types have soft, chewable seeds. Actual seed counts have ranged from 112 to 535 but some guavas are seedless or nearly so. When immature and until a very short time before ripening, the fruit is green, hard, gummy within and very astringent.

## Cultivar

Formerly, round and pear-shaped guavas were considered separate species *P. pomiferum*L. and *P. pyriferum*L. but they are now recognized as mere variations. Small, sour guavas predominate in the wild and are valued for processing.

**Redland:**The first named cultivar in Florida, it was at first considered promising but because of its excessively mild flavor, low ascorbic acid content, and susceptibility to algal spotting, it was abandoned in favor of better selections.

**Supreme:**Came next, of faint odor, thick, white flesh, relatively few, small seeds, high ascorbic acid content and ability to produce heavy crops over a period of 8 months from late fall to early spring.

**Red Indian:**of strong odor, medium to large size, round but slightly flattened at the base and apex, yellow skin often with pink blush; with medium thick, red flesh of sweet flavor; numerous but small seeds; agreeable for eating fresh; fairly productive in fall and early winter.

**Ruby:** With pungent odor, medium to large size; ovate; with thick, red flesh, sweet flavor, relatively few seeds. An excellent guava for eating fresh and for canning,and fairly productive mainly in fall and early winter.

**Blitch:**(a seedling which originated in West Palm Beach and was planted at Homestead) of strong odor, medium size, oval, with light-pink flesh, numerous, small seeds; tart, pleasant flavor; good for jelly.

**Patillo**: a seedling selection at Deland propagated by a root sucker and from that by air-layer and planted at Homestead) of very mild odor, medium size, ovate to obovate, with pink flesh, moderate number of small seeds; sub acid, agreeable flavor; good for general cooking. (As grown in Hawaii it is highly acid and best used for processing).

**Miami Red**and **Miami White:** large, nearly odorless and thick-fleshed, were released by the University of Miami's Experimental Farm in 1954.

## Ecological Requirements

The guava thrives in both humid and dry climates. It can survive only a few degrees of frost. Young trees have been damaged or killed in cold spells. Older trees, killed to the ground, have sent up new shoots which fruited 2 years later. The guava requires an annual rainfall between 1,000-2,000 mm; is said to bear more heavily in areas with a distinct winter season than in the deep Tropics.

The guava seems indiscriminate as to soil, doing equally well on heavy clay, marl, light sand, gravel bars near streams, or on limestone; and tolerating a pH range from 4.5 to 9.4. It is somewhat salt-resistant. Good drainage is recommended but guavas are seen growing spontaneously on land with a high water table–too wet for most other fruit trees.

## Pollination

The chief pollinator of guavas is the honeybee (*Apismellifera).* The amount of cross-pollination ranges from 25.7 to 41.3%.

## Cultural Practice/Crop Husbandry

**Propagation**

Guava seeds remain viable for many months. They often germinate in 2 to 3 weeks but may take as long as 8 weeks. Pretreatment with sulfuric acid, or boiling for 5 minutes, or soaking for 2 weeks, will hasten germination. Seedlings are transplanted when 2 to 30 in (5-75 cm) high and set out in the field when 1 or 2 years old. Inasmuch as guava trees cannot be depended upon to come true from seed, vegetative propagation is widely practiced.

* Pruned branches may serve as propagating material. Cuttings of half-ripened wood, 1/4 to 1/2 in (6-12.5 mm) thick will root with bottom heat or rooting-hormone treatment.
* Approach grafting yields 85 to 95% success.
* a system of patch budding has been demonstrated as commercially feasible in India

**Culture:-** Guava trees are frequently planted too close. Optimum distance between the trees should be at least 10 m. Planting 5 m apart is possible if the trees are "hedged". The yield per tree will be less but the total yield per land area will be higher than at the wider spacing.

Light pruning is always recommended to develop a strong framework, and suckers should also be eliminated around the base. Fruits are borne by new shoots from mature wood. If trees bear too heavily, the branches may break. Therefore, thinning is recommended and results in larger fruits.

Guava trees grow rapidly and fruit in 2 to 4 years from seed. They live 30 to 40 years but productivity declines after the 15th year. Orchards may be rejuvenated by drastic pruning. The tree is drought-tolerant but in dry regions lack of irrigation during the period of fruit development will cause the fruits to be deficient in size. The fruit matures 90 to 150 days after flowering.

## Harvesting and Postharvest Handling

Ripe guavas bruise easily and are highly perishable. Fruits for processing may be harvested by mechanical tree-shakers and plastic nets. For fresh marketing and shipping, the fruits must be clipped when full grown but under ripe, and handled with great care. After grading for size, the fruits should be wrapped individually in tissue and packed in 1 to 4 padded layers with extra padding on top before the cover is put on.

Fruits coated with a 3% wax emulsion will keep well for 8 days at 22.2 º-30 º C and 40 to 60% relative humidity and for 21 days at 8.3º-10º C and relative humidity of 85-90%. Storage life of mature green guavas is prolonged at (20º C), relative humidity of 85%, less than 10% carbon dioxide, and complete removal of ethylene.

## Pests of Guava

Guava trees are seriously damaged by the citrus flat mite, *Brevipa1pus californicus*in Egypt. In India, the tree is attacked by 80 insect species, including 3 bark-eating caterpillars *(Indarbella*spp.) and the guava scale, but this and other scale insects are generally kept under control by their natural enemies. The green shield scale, *Pulvinariapsidii,* requires chemical measures in Florida, as does the guava white fly, *Trialeurodesfloridensis,* and a weevil, *Anthonomusirroratus,* which bores holes in the newly forming fruits.

The guava fruit worm, *Argyresthiaeugeniella,* invisibly infiltrates hard green fruits, and the citron plant bug, *Theognisgonagia,* the yellow beetle, *Costalimaitaferruginea,* and the fruit-sucking bug, *Helopeltisantonii,* feed on ripe fruits. A false spider mite, *Brevipalpusphoenicis,* causes surface russeting beginning when the fruits are half-grown. Fruit russeting and defoliation result also from infestations of red-banded thrips, *Selenothripsrubrocinctus.* The coconut mealy bug, *Pseudococcusnipae,* has been a serious problem in Puerto Rico but has been effectively combatted by the introduction of its parasitic enemy, *Pseudaphycusutilis.*

The guava is a prime host of the Mediterranean, Oriental, Mexican, and Caribbean fruit flies, and the melon fly*–Ceratitiscapitata, Dacusdorsalis, Anastrephaludens, A. suspensa,* and *Dacuscucurbitae.* Ripe fruits will be found infested with the larvae and totally unusable except as feed for cattle and swine. To avoid fruit fly damage, fruits must be picked before full maturity and this requires harvesting at least 3 times a week.

Severe losses are occasioned by birds and bats and some efforts are made to protect the crop by nets or noisemakers.