**Bonga University**

**College of Agricultural and Natural Resource**

**Department of Plant Science**

**Degree Program: BSc in Plant Science**

**Module Name: Horticultural Crops Production and Processing**

**Course Title: Fruit Crops Production and Management**

**Course Code**: Plsc3094

**Instructor`s name**: Getachew B. (Msc.)

**E-Mail:** **gechbir353@gmail.com**

ECTS Credits (CP) 5

Target Group: Plant Science Students

Year/Semester Year 3, Semester II

Status of the course: Core

**Chapter one**

**INTRODUCTION**

* At the end of this chapter students should be able to:
* Define horticulture and understand the nature of horticultural crops
* Define and classify fruits
* Explain the importance of fruits
* Describe the present status and future potentials of fruit production in Ethiopia
* Identify problems associated with fruit production in Ethiopia

**1.1 What is horticulture?**

* It is a science that deals with the production, cultivation, processing and marketing of horticultural crops like fruits, vegetables and nuts, coffee, tea, root and tuber crops, spice and ornamental

**The nature of horticultural crops**

* + High yield per unit area
	+ Require high capital, labor and technology and input per unit area
	+ Have short shelf life because of their perishable nature
	+ Largely utilized in fresh or as living state
	+ Uses intensive farming

**1.2 Division of horticulture**

* **Pomology** – is a science study about cultivation of fruit crops production. e.g. Mango, Guava, Grape, Banana, etc.
* **Citiriculture** – is study about citrus crop production and management
* **Viticulture** – is a science deals about the grape vine production and management
* **Olericulture** – is deals about the cultivation of vegetables. e.g. Okra, Tomato, Pumpkin, etc.
* **Arboriculture** – is deals about individual trees, shrubs, and other perennial woody plants
* **Floriculture** - is a science study about flower crops or Ornamental plants.
* **Landscape** **gardening**: It deals with the planning and execution of ornamental gardens, parks, landscape gardens etc

**1.3 Definition and Classification of Fruits**

* What is fruit? And what about seeds?
* **Botanically:** Is matured ovary
* **Horticulturally:-** A matured ovary with or without structures.
* But at commercial level from their feature of horticulture they are regarded as fruits.
* The fruit does not develop only from ovary but sometimes develop from ovary + accessory parts.

**Morphologically, fruits possess three layers**

* a. Exocarp (skin) - outer covering part of fruits
* b. Mesocarp (middle layer) – the edible part of fruits and
* c. Endocarp – the central hard stone part of fruits

**1.3.1 Classification of Fruits**

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

**i. Simple fruits -** Developed from single flower and single ovary. Example: apple

**ii) Aggregate fruits -** Developed from single flower that contains many ovary Example:          strawberry, raspberry

       **iii) Multiple fruits -** Develop from many flowers with many ovaries, example: pineapple

2**. Classification Depending on Ripening Process**

   A. Climacteric Fruits –

* Fruits need further ripening period,
* In very general terms a climacteric fruit can be picked from the tree at full size or maturity but before it is 'ripe' (Horticultural maturity) and allowed to ripen off the tree
* The climacteric - is a stage of fruit ripening associated with ethylene production and cell respiration rise
* Climacteric is the final physiological process that marks the end of fruit maturation and the beginning of fruit senescence
* The climacteric event also leads to other changes in the fruit including pigment changes and sugar release
* After the event fruits are more susceptible to fungal invasion and begin to degrade with cell death

**B. Non Climacteric Fruits**

* Non climacteric fruit is a type of fruit that only picked from the tree at full size (maturity) after it is 'ripen' (Horticultural maturity) and allowed to ripen on the tree
* Citrus, grapes, strawberries are non-climacteric (they ripen without ethylene and respiration bursts)
* However, there are non-climacteric melons and apricots, and grapes and strawberries harbor

**3. Classification Based on Whether Fruits are Leaf Shedding or Not**

 **a. Deciduous** - These are 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.

 **b. 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, Pineapple, Mango, Papaya, Guava, Citrus, Passion fruit, Avocado etc.

**4. Classification based on climatic requirements (Climatic Adaptation)**

 1. The tropical, lies 0-20°,

 2. The subtropical 20-30° and

 3. Temperate 30-60° north and south from the equator

* several ethylene receptors which are active
* **Tropical fruits -** Do not withstand freezing temperatures, and many do not grow well if temperatures drop below 10°C
* **Subtropical fruits -** Grown at low altitudes in those parts of the temperate zones nearest the equator,
* tolerates some subfreezing temperatures but are killed or severely injured below about 9.5°C,
* **Temperate fruits-**Temperate-zone regions of the northern and southern hemispheres,
* 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

**1.4 Importance of fruit production in Ethiopia**

* Fruits are an important part of a healthy diet and have many social and economic values such as:

 a. Food: Fruits are ready made food.

 b. Nutritional value: Most fruits are rich source of vitamins and minerals; good source of       carbohydrate, Protein, calories, fat & oil (Avocado); Protein & oil (Nut);

 c. Social & economic importance

**1.5 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 introduced by diplomats, merchants, and native scholars

* At present these fruits are produced at different levels:
* peasant holdings (small gardens/ back yards),
* small scale farms and
* large scale farms (both government and private owned)
* Normally, peasants use seedlings raised from seeds collected from cultivars of unknown origin
* In addition to this, they follow old aged cultural practices
* 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

* 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)
* Even though their importance, ecological adaptation and genetic resources, no attention has been given either to domesticate or even protect them in their natural habitat
* There is an urgent need for means and strategies to protect and exploit them to the best of our advantage

**1.6 Problems Associated with Fruit Production in Ethiopia**

 1**. Absence of broad genetic base -** The number of cultivars in use is very limited

 2**. Poor knowledge of the society** about the nutritional value of fruits nutritional advantage               of fruits was not well known

 3**. L*ack of improved planting material and production technology*** *-* there is a lack of                  improved planting material and production technologies

4**. Lack of appropriate post-harvest technology -** due to lack of proper handling and                   transportation facilities

 ***5.* Disease and insect pest problem** *- diseases* and insect pests are known to cause serious                       damage to cultivated fruits

 ***6.* Marketing** - drop in price of fresh fruits and so lowers the moral of farmers and                                    discourages better management or further expansion

**1.7 Future Fruit Production Potentials of Ethiopia**

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

a. Favorable agro-ecological conditions

 - Climate-

 ***-*** Soils

 b. Market

 - Local markets

 - Export markets: - Ethiopia is exporting some fruits, notably banana and citrus to                                 nearby countries like Djibouti, Saudi Arabia, Italy and others.

**CHAPTER TWO**
**Principles and Techniques of Propagating Fruit Crops**

* Plant propagation is the art and science of increasing numbers of plants
* Plant propagation is the process of creating new plants
* Successful plant propagation depends on a series of factors, all of which need to take place before a plant is reproduced
* From seed germination to the successful rooting of cuttings, certain principles must first be understood before a plant propagator can perfect methods for growing plants
* There are two types of propagation: **sexual** and **asexual**.
* **Sexual reproduction** is the union of the pollen and egg, drawing from the genes of two parents to create a new, third individual.
* **Sexual propagation** involves the floral parts of a plant.
* sexual methods as seeds and spores
* **Asexual propagation** involves taking a part of one parent plant and causing it to regenerate itself into a new plant.
* The resulting new plant is genetically identical its parent.
* Asexual propagation involves the vegetative parts of a plant: stems, roots, or leaves
* Asexual methods like cuttings, layers, divisions, natural reproductive structures such as bulbs,  grafting, and in vitro micro-propagation

1. **Sexual (Seed) Propagation:-**

* Is a process by which plants reproduce by the transfer of pollen from one plant fertilizes the ovary from another, producing one or more seeds
* Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed.
* The plants which multiply through seeds as a mode of perpetuation.
* Example: Most annuals, biennials and many perennial fruit plants;
* vegetable crops
* plantation,
* aromatic and medicinal plants
* ornamental flowering and
* shade providing shrubs and trees etc.
* In sexual method of propagation, the sex organs of flower are involved in process like pollination and fertilization leads to the formation of seeds.
* Seeds are typically produced from sexual reproduction within a species may have different characteristics from its parents.
* In a number of species, sexual reproduction produces plans that are too variable for commercial production

*What is seed and what are the main parts of a given seed?*

* Seed is the end result of the sexual fertilization and
* The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself
* A seed is, "botanically a matured ovule containing an embryo that is usually the result of fertilization".
* A seed forms as a result of the combination of the mature male and female gametes
* By producing and releasing seed, a plant is ensuring the survival of its species, as long as the habitat is desirable
* **To obtain quality plants the seed must be**
* Start with good quality seed from a reliable dealer.
* Select varieties to provide the size, color, and habit of growth desired.
* Choose varieties adapted to your area w/c will reach maturity before an early frost
* Hybrid plants usually have more vigor, more uniformity, and better production than non-hybrids and
* Sometimes have specific disease resistance or
* Other unique cultural characteristics.
* Quality seed will not contain seed of any other crop, weeds, seeds or debris.
* On the seed packet usually indicates essential information about the variety
* The year for which the seeds were packaged, and
* Germination percentage you may typically expect, and
* About any chemical seed treatment

*Define germination and explain the environmental conditions required for a given seed to germinate*?

* Seed Germination: - is applied to the resumption of the growth of the seed embryo after the period of dormancy
* When a seed is mature and put in a favorable environment, it will germinate (begin active growth).
* Germination does not take place unless the seed has been transported to a favorable environment by one of the agencies of seed dispersal
* Germination will begin when certain internal requirements have been met.
* A seed must have a mature embryo
* It contains a large enough endosperm to sustain the embryo during germination,
* And contain sufficient hormones to initiate the process.
* In general, do not expect more than 65% to 80% of new seeds to germinate.
* From those germinating, expect about 60% to 75% to produce satisfactory, vigorous and sturdy seedlings.
* There are three major environmental factors which affect germination: water, oxygen, and temperature, sometime light considered as factor
* The primary conditions of a favorable environment are adequate water and oxygen and suitable temperature

**Water**

* The first step in the germination process is the imbibitions or absorption of water.
* Even though seeds have great absorbing power due to the nature of the seed coat.
* The amount of available water in the substrate affects the uptake of water.
* An adequate, continuous supply of water is important to ensure germination.
* Once the germination process has begun, a dry period can cause the death of the embryo.

**Oxygen**

* In all viable seed, respiration takes place.
* The respiration in dormant seed is low, but some oxygen is required.
* The respiration rate increases during germination
* Therefore, the substrate in which the seeds are placed should be loose and well-aerated.
* If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.

**Temperature**

* A favorable temperature is another important requirement of germination.
* It not only affects the germination percentage but also the rate of germination.
* Some seeds will germinate over a wide range of temperatures
* Whereas others require a narrow range.
* Many seeds have min, max and optimum temperatures at which they germinate.
* The importance of maintaining proper temperature to achieve maximum germination percentages.
* Different species of plants germinate best in different temperatures;
* as a rule, extremely cold or extremely warm temperatures do not favor germination
* Some seeds also require adequate exposure to light before germinating

***Define seed dormancy and explain the methods of overcoming seed dormancy?***

* Seed Dormancy:- A dormant seed is the one that is unable to germinate in a specified period of time under a combination of environmental factors
* Such as water, light, temperature, gases, mechanical restrictions, seed coats and hormone structures
* Seed dormancy can also be defined as a state in which seeds are prevented from germinations even under environmental conditions normally favorable for germination
* One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment.
* In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal.

**Ways to Overcome Dormancy: -** Mechanisms to overcome dormancy

* Various treatments are performed on the seed to break dormancy and begin germination.

**Scarification**

* Seed scarification involves breaking, scratching, or softening the seed coat
* So that water can enter and begin the germination process.
* There are several methods of scarifying seeds.
* **In acid scarification**, seeds are put in a glass container and
* Covered with concentrated sulfuric acid.
* The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat.
* When the seed coat has become thin, the seeds can be removed, washed, and planted.

**Another scarification method** is mechanical.

* **Seeds are filled with a metal file**, rubbed with sandpaper, or
* Cracked with a hammer to weaken the seed coat.
* **Hot water scarification (**Maceration of seeds**)** involves putting the seed into hot water (170 to 212 degrees F).
* The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted.
* A fourth method is one of **warm, moist** **scarification**.
* In this case, seeds are stored in non sterile, warm, damp containers where the seed coat will be broken down by decay over several months.

**Stratification**

* Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they over winter.
* **Physiologically Immature Embryo** - Dormancy stratification is a common technique                 whereby the seed is stored in moist conditions
* This so called “after ripening” may be accomplished artificially by a practice called stratification.
* The following procedure is usually successful.
* Put sand or vermiculite in a clay pot to about 1 inch from the top.
* Place the seeds on top of the medium and
* Cover with ½ inch of sand or vermiculite.
* Wet the medium thoroughly and
* Allow excess water to drain through the hole in the pot.
* Place the pot containing the moist medium and seeds in a plastic bag and seal.
* Place the bag in a refrigerator.
* Periodically check to see that the medium is moist, but not wet.
* Additional water will probably not be necessary.
* After 10 to 12 weeks, remove the bag from the refrigerator.
* Take the pot out and set it in a warm place in the house.
* Water often enough to keep the medium moist.
* Soon the seedlings should emerge.
* When the young plants are about 3 inches tall, transplant them into pots to grow until time for setting outside.

 **Major Merits of Sexual Propagation**

* High root –to- shoot ratio of the younger plant
* Disease free planting material
* Easy to operate or cheapest method
* As a result of hybridization, new variety can be developed
* Planting material (seed) can be stored for longer period of time

**Major Demerits of Sexual Propagation**

* Tall in growth- difficult to manage
* Low yielder
* Heterozygous (genetically variable)
* Long Juvenile period – long time to bear fruits for example grape from seed needs 7-8 years but grape from cutting (vegetative) need 3 to 4 years.
* Susceptible to major pests and disease
* Difficulty of germination in some seeds

**2. Asexual Propagation Methods**

* Propagation by apomictic seedlings
* Apomictic seedlings are identical to their mother plants,
* And similar through the plants raised through other vegetative means, as it has the same genetic makeup as that of the mother plants.
* It is also called vegetative propagation that it involves only vegetative parts without any sexual plant parts.
* Asexual propagation is the best way to maintain some species, particularly an individual that best represents that species.
* Clones are groups of plants that are identical to their one parent and
* that can only be propagated asexually
* The major methods of asexual propagation are cuttings, layering, division, budding and grafting.
* Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent and then severing it
* And budding and grafting is joining two plant parts from different varieties.
* It involves the vegetative parts of a plant including the roots, stems or leaves

**There are several advantages to propagating plants asexually**

* It may be the easiest and fastest way to propagate some species of plants.
* It may be the only way to perpetuate some cultivars, (problematic seed germination and storage)
* Maintaining superior genotypes
* Shortening time to flower and fruit (it bypasses the juvenile characteristics of certain species).
* Combining desirable characteristics of more than one genotype into a single plant
* Uniformity of plantations
* Fruit Plant and Tree Propagation Categories

**The methods to propagate asexually fruit plants are classified in two main and six sub        categories:**

* Rooting
* Stock Division
* Propagation by Suckers
* Propagation by Runners
* Layering
* Propagation by Cuttings
* Plant Union o Propagation by Graftage ƒ
* Bud Grafting (Budding) ƒ
* Grafting
* **The major methods of asexual propagation are cuttings, layering, grafting and budding**

**1. Cuttings: -** involve rooting a severed piece of the parent plant, while layering involves rooting                   a part of the parent plant and then severing it,

* **Budding** and **grafting** involve joining two plant parts from different varieties,

 **A. Cuttings**

* Many types of plants, both woody and herbaceous, are frequently propagated by                             cuttings.
* A cutting is a vegetative plant part which is severed from the parent plant in order to     regenerate itself, thereby forming a whole new plant.
* Cuttings can be classified according to the parent of the plant from which they               are obtained: Stem cuttings, leaf cuttings, leaf-bud cuttings, and root cuttings

 **i. Stem cutting: -** is one of the most important types in fruit propagation.

* Numerous plant species are propagated by stem cuttings.
* Some can be taken at any time of the year,
* But stem cuttings of many woody plants must be taken in the fall or in the dormant     season.
* According to the nature of the wood used these could be: *hardwood, semi-hardwood    and softwood*
* Numerous plant species are propagated by stem cuttings.
* Some can be taken at any time of the year,
* But stem cuttings of many woody plants must be taken in the fall or in the dormant     season.
* Application of certain chemicals promotes the development of roots and/or shoots of           stem cuttings
* Such as like Indole acetic acid (IAA), indole butyric acid (IBA), and
naphthalene acetic acid (NAA)
* These chemicals not only speed up the healing of the wound and the formation of roots,           but they also induce the development of a large number of roots

 **A. Hardwood cuttings** – There are two types of hardwood cuttings.

* Those that are taken from deciduous plants (such as mulberry, grape, apple, plum,    peach, pomegranate and figs and
* Those that are taken from evergreen plants (such as olive and granadilla).
* Hardwood cuttings are taken from deciduous plants in early winter after the plants      have dropped their leaves
* Those made of matured, dormant hardwood after leaves have dehisced and before new      shoots emerge
* Generally the cuttings of 15-20 cm length and having 3-5 buds are preferred    depending upon species.
* While preparing the cutting, a straight cut is given at the base of shoot below the node    while a slanting cut 1-2 cm above the bud is given at the top,
* In Ethiopia, grapes are typical deciduous fruit plants, which are commonly propagated    by **matured vine (canes)**

 **B. Semi-hardwood** - cuttings are those made from woody, broad-leaved species

* These types of cuttings are usually made from woody evergreen plants, which are    taken during the growing season.
* They are cut off before the wood hardens and turns brown.
* Cuttings are used from the leafy shoot tip.
* The length of cutting varies from 7-20 cm.
* The cuttings are prepared by trimming the cutting with straight cut below a node and      removing a few lower leaves.
* However, it is better to retain two to four leaves on the top of cuttings.
* Treating the cutting with 5000 ppm IBA (an rooting hormone) before planting gives       better result.
* The best time of taking cutting is summer when new shoots is emerged and their wood        is partially matured.
* When the cuttings have developed their root systems, we can then transplant each one        into a larger container.
* We use this propagation technique for the reproduction of coffee, kiwi, litchi,          macadamia, mango, granadilla and pomegranate plants.
* Partially matured wood of deciduous fruit plants could also be considered as semi hardwood
* Keeping basal end (bottom) of the cuttings relatively warm and growth-regulator treatments are also beneficial

 **C. Softwood cuttings** - are prepared from the soft, succulent, new growth of deciduous or                        evergreen species.

* Detach a 2 to 6-inch piece of stem, including the terminal bud.
* This simple cutting is done on a stem, which usually contains 4-6 buds.
* Make the cut just below a node.
* Remove lower leaves that would touch or be below the medium.
* Dip the stem in rooting hormone if desired.
* Gently tap the end of the cutting to remove excess hormone.
* Insert the cutting deeply enough into the media to support itself.
* If the cutting originated from an evergreen plant, the bottom two leaves should be    removed and planted immediately after being cut.
* At least one node must be below the surface.
* The shoots will then grow from the buds above the soil and the roots will grow from the nodes in the soil.
* Typical examples for the use of this method are the Fig lime, lemon and Olive.
* Soft wood cuttings generally root easier and quicker than the other types but require more attention and equipment
* This type of cutting is always made with leaves attached
* **Herbaceous cuttings** *-* Pineapple is a herbaceous fruit plant,
* cuttings of which exude a sticky sap and do better if the basal ends are allowed to dry for a few hours before they are inserted in the rooting medium

**ii. Leaf Cuttings**

* Leaf cuttings comprise whole leaves with or without petiole
* The cuttings are taken from plants that are thick and succulent.
* Adventitious shoots form at the base of the parent leaf and the original leaf rarely becomes part of a new plant

 Fig. 1 

* **Leaf bud cuttings:** comprises a leaf blade and petiole together with a small portion of the stem to which the leaf is attached and includes the auxiliary bud at the base of the petiole

Fig. 2 ****

**iii. Root cuttings**

* Root cuttings are usually taken from young plants in early spring or late winter, before    they start growing
* Root cuttings are usually taken from 2 to 3 year old plants during their dormant season    when they have a large carbohydrate supply.
* Root cuttings of some species produce new shoots, which then form their own root    systems.
* While root cuttings of other plants develop root systems before producing new shoots.
* Healthy roots have ample food (carbohydrates) stored to support shoot development at    this time,
* Optimum temperatures for most root cuttings range from 13°C to 18°C,
* Root cuttings may be transplanted after shoots have emerged and sufficient new   secondary roots have developed,
* Root Cuttings Take root cuttings about 1 meter away from the tree trunk.
* These cuttings should be 20-25 cm long and 1-2 cm thick.
* Place these cuttings horizontally into the soil about 10 cm deep until they shoot.
* This technique is useful for propagation of guava, breadfruit, apple, blackberry and     raspberry.

Root Cuttings

 
Fig. 3

* Source: Forestry Commission, Harare

**Selection of Materials for Cuttings:**

* Select stock plants that are healthy, vigorous and of known cultivar
* Cuttings taken from young plants or shoots root better than those taken from old plants or shoots
* Take cuttings either before or after flowering. Don’t use flowering shoots for cuttings
* **Physiological Basis of Rooting -** The capacity of stem to root is known to be influenced  by the interaction of:
* Inherent factors present in the stem cells and
* Transportable substances, such as Auxin, carbohydrate and nitrogenous compounds, produced in leaves and buds,

 **i. Effect of hormones on rooting –**

* Auxin: - is synthesized primarily in apical buds and young leaves and have     basipetal movement.
* IAA- promotes rooting
* Cytokinnins (Ck) (natural) ; Low CK favor adventitious root formation and
* low Auxin: high Ck favors adventitious bud formation – difficult to root
* Gibberellins (GA): promote stem elongation
* Absicic Acid (ABA): retard both root and shoot initiation

**ii. Effect of buds and leaves on rooting**

* Presence of leaves and buds strongly influence the rooting of stem cutting. How?
* Buds are sources of Auxin while the leaves are primary sources of carbohydrate,

**iii. Type of stem cutting**

* Softwood cuttings plants root easily than hardwood,

**iv. Environmental factors -** Temperature: optimum air temperature for rooting during the day                             ranges from 21-270C and 16-210C during the night

* Humidity and moisture: the rooting medium and the air surrounding the cuttings must have an adequate and uniform moisture,
* High relative humidity can be maintained by use of mist

**v. Rooting media**

* The rooting medium should be disease and pest free and provide adequate moisture and oxygen,

**2. Layering**

* Stems still attached to their parent plants may form roots where they touch a rooting medium,
* Layering is enhanced by girdling the stem where it is bent, by wounding one side of the stem or by bending it very sharply,
* The rooting medium should always provide aeration and a constant supply of moisture,

**Most common types of layering**

 a. **Tip layering -** Insert the shoot tip and cover it with soil.

* Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil.
* The tip grows downward first, then bends sharply and grows upward.
* Roots form at the bend, and the recurved tip becomes a new plant.
* Remove the tip layer and plant it in the early spring or late fall.
* Examples: purple and black raspberries, trailing blackberries.

                              Fig. 4                     ****

 b. **Simple layering**

* Bend the stem to the ground
* Cover part of it with soil, leaving the last 6 to 12 inches exposed.
* Bend the tip into a vertical position and stake in place.
* The sharp bend will often induce rooting,
* but wounding the lower side of the branch or loosening the bark by twisting the stem may help.

                Fig. 5             

 c. **Compound layering** - This method works for plants with flexible stems

* This method works for plants with flexible stems.
* Bend the stem to the rooting medium as for simple layering.
* But alternately cover and expose stem sections.
* Wound the lower side of the stem sections to be covered.

 Fig. 6 

 d. **Mound (Stool) Layering**

* Cut the plant back to 1 inch above the ground in the dormant season.
* Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries, apple rootstocks



Fig. 7

e**. Air layering** - It involves the girdling of a relativelyyoung shoot.

* This method is used on the tip of the branch, when stems are usually younger then one year old.
* A strip of bark is cut approximately 2 cm wide on the stem about 20 cm from the tip (just below a leaf stalk, or join).
* Once cut, a rooting hormone is applied and rooting material is placed under the strip.
* Finally, the cut is covered with a thin plastic bag, which is opened at both ends.
* Rooting material must be placed in the bag before it is sealed.
* This process must be completed during rainy conditions
* When the air humidity is highest.
* Litchi, guava, macadamia and mango are propagated with this method.

Air layering



Fig.8

3. **Grafting**

* Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant
* It is a technique of connecting two pieces of living plant tissue together so that they will unite and form a functional plant.
* Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant.
* These techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate.
* One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.
* The portion of the cultivar that is to be propagated is called the scion.
* It consists of a piece of shoot with dormant buds that will produce the stem and branches.
* The rootstock, or stock, provides the new plant’s root system and
* sometimes the lower part of the stem.
* The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate. Example apple.
* **Scion** - the aerial part of a tree that will form the crown of the new plant
* **Rootstock -** the below-ground or lower part of a tree
* **Vascular cambium -** thin layer of meristematic cells between a trees’ bark (phloem) and wood (xylem)
* **Callus (tissue):** a mass of undifferentiated cells formed around a plant wound
* From the callus cells, new vascular tissue develop that will allow scion and rootstock to function as one plant

**The following four conditions must be met for grafting to be successful:**

 i. The scion and rootstock must be compatible;

 ii. Each must be at the proper physiological stage;

 iii. The cambial layers of the scion and stock must meet; and

 iv. The graft union must be kept moist until the wound has healed

**Factors influencing grafting success**

 a. Inherent compatibility

 b. skillful grafting or budding techniques

 c. Environmental factors: 26-30°C is optimum for callus formation

 d. Time of grafting and condition of the plant

 e. Disease and pests (interfere healing of the union)

**Methods of Grafting**

**Cleft grafting**

* Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree, usually a seedling (to rehabilitate the older plants)
* It is especially successful if done in the early spring.
* Collect scion wood 3/8 to 5/8 inch in diameter.
* Cut the limb or small tree trunk to be reworked, perpendicular to its length.
* Make a 2-inch vertical cut through the center of the previous cut.
* Be careful not to tear the bark. Keep this cut wedged apart.
* Cut the lower end of each scion piece into a wedge.
* Prepare two scion pieces 3 to 4 inches long.
* Insert the scions at the outer edges of the cut in the stock.
* Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch.
* Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.



**Fig. 9**

 **B. Whip or Tongue grafting:** Useful for grafting relatively small material, ¼ to ½ inch in              diameter

* It is the simple and popular propagation method used in apples and widely used in pear.
* This method is commonly used when the stock and scion are of equal diameter.
* Each scion sticks should contain at least two to three sets of buds.
* Identical cuts are made at the top of the rootstock and bottom of the scion, so the two pieces fit together nicely.
* About one-year-old rootstock is headed back at a height of 23-25 cm from the soil and a diagonal cut is made at the distal end ( the point of attachment) of the rootstock.
* A similar slanting cut is made on the proximal end of the scion.
* On the cut surface, slice downward into the stock and up into the scion so the pieces will interlock
* The cut surface of both rootstock and scion are bound together and tied firmly.
* The scion having 2 to 3 buds is then tightly fitted with the rootstock taking care that the cambium layer of at least one side of the stock and scion unites together.
* This strong graft heals quickly and provides excellent cambial contact.

 **C. Bark grafting-** Bark grafting is used when the stock is too large for whip grafting

* Unlike most grafting methods, bark grafting can be used on large limbs, although these are often infected before the wound can completely heal.
* Collect scion wood 3/8 to 1/2 inch in diameter when the plant is dormant, and
* store the wood wrapped in moist paper in a plastic bag in the refrigerator.
* Saw off the limb or trunk of the rootstock at a right angle to itself.
* In the spring, when the bark is easy to separate from the wood,
* make a 12-inch diagonal cut on one side of the scion, and
* A 1½-inch diagonal cut on the other side. Leave two buds above the longer cut.
* Cut through the bark of the stock, a little wider than the scion.
* Remove the top third of the bark from this cut.
* Insert the scion with the longer cut against the wood.
* Nail the graft in place with flat-headed wire nails.
* Cover all wounds with grafting wax.
* It is one of the most difficult grafting techniques F Fig. 10

 **D. Side grafting**: the scion is inserted into the side of the stock, which is generally larger in             diameter than the scion

  Fig. 11                           

 **E. Wedge grafting;** This method is one of the most difficult propagation techniques

* **Approach grafting:** Two independent, self sustaining plants are grafted together
* Therefore, both scion and stock continue photosynthesis and absorption process during the period of healing

**Repair grafts:**

* In addition to its role as a method of propagation grafting is useful for repair; invigoration and cultivar change of old established trees
* **Inarching-** involves reinforcing of the existing root system

**Bridge grafting-** a form of repair grafting used in cases where root system of the tree has not been damaged but there is injury to the bark of the trunk

**4. Budding**

* A special form of grafting in which the scion consists of a single bud
* It is a more economical form of grafting
* It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting

**Methods of Budding**

 **1. T-budding-** This is the most commonly used budding technique

 **2. Inverted T-budding-** Preferred in cases where there is heavy rain in the locality and in               species which bleed badly during budding

* In some species its use is not conducive to normal and rapid growth

**3. Patch budding -** Plants with thick bark should be patch-budded

* This is done while the plants are actively growing so their bark slips easily
* Remove a rectangular piece of bark from the rootstock.
* Cover this wound with a bud and matching piece of bark from the scion.
* If the rootstock’s bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped the patch will be held firmly in place.
*  Fig. 12

**4. Chip budding**

* This budding method can be used when the bark is not slipping
* This budding method can be used when the bark is not slipping.
* Slice downward into the rootstock at a 45 degree angle through 1/4 of the wood.
* Make a second cut upward from the first cut, about one inch.
* Remove a bud and attending chip of bark and wood from the scion shaped so that it fits the rootstock wound.
* Fit the bud chip to the stock and wrap the union.

**Rootstocks for budding**

* Rootstocks should have vigorous growth habit, disease and pest resistance as well as being easily propagated

**Reasons for grafting and budding**

a. Perpetuation of clones not conveniently propagated by other methods

b. Benefits of certain rootstocks are obtained, such as vigor, dwarfing effect

c. Changing cultivars of established plants

d. Repairing damaged parts of trees. Bridge grafting and inarching

**Division**

* Plants with more than one rooted crown may be divided and the crowns planted separately.
* If the stems are not joined, gently pull the plants apart.
* If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury.
* Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: dahlias, iris, rhubarb, day lilies, Banana, Ginger and turmeric.

 ** **

**Fig. 13**

**Separation**

* Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.

**Bulbs:** New bulbs form beside the originally planted bulb.

* Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb population.
* Dig up the clump after the leaves have withered.
* Gently pull the bulbs apart and replant them immediately so their roots can begin to develop.
* Small, new bulbs may not flower for 2 or 3 years,
* but large ones should bloom the first year. Examples: tulip, narcissus.

**Corms**

* A large new corm forms on top of the old corm, and
* tiny cormels form around the large corm.
* After the leaves wither, dig up the corms and
* allow them to dry in indirect light for 2 or 3 weeks.
* Remove the cormels,
* and then gently separate the new corm from the old corm.
* Dust all new corms with a fungicide and store in a cool place until planting time. Examples: crocus, gladiolus. Enset

                                

Fig. 14

**CHAPTER THREE**

**NURSERY ESTABLISHMENT AND MANAGEMENT**

* **Nursery** is a place where plants are cared for during the early stages of growth, providing optimum conditions for germination and subsequent growth

**Why we need to establish nursery?**

 1. To give seeds better condition for germination.

 2. To apply optimum growing conditions to the fruit plants

 3. To economized on seeds.

 4.To avoid weak and diseased plants so as to obtain uniform seedlings

**3.1 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
* Not previously planted under the same fruit crop
* In an area not prone to frost
* Near a source of water for irrigation
* Protected from strong winds
* There should be the accessibility of roads for the transport

**3.2. Nursery bed preparation**

* Nursery row cultureis a basic nursery operation used for outdoor seed propagation of fruit trees
* **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)
* **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 critical factors that determines the rate of emergence and perhaps       stand density
* Large seed (e.g., avocado) can be planted 10 to 15cm deep, medium-sized seed (e.g., citrus, bullock's heart) about 7.6 cm, and small seed (e.g., guava, passion fruit) about 3.8cm
* 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 optimum seed densitydepends primarily on the species but also depends on the nursery objectives

**Propagation structures**

* Structures range from simple shade house to complex and automated greenhouses, which vary in the extent to which they control the environment

**Potting soils**

* When soil is removed from the field and placed in a container its properties change drastically
* If a high quality nursery stock is to be produced a good potting soil must
* Adequately support the plant
* Provide a reservoir for air, moisture, and nutrients
* Supply all the nutrients the plant needs both i.e., both macro and micro nutrients
* A Soil mix should also be stable enough to ensure that its properties do not change drastically during the period of plant growth
* Materials which tend to compact or organic matter which tends to decompose rapidly are not satisfactory

**Raising seedlings in plastic tubes**

* This technique 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

**Watering**

* The seed beds should be watered immediately after sowing
* Inspect the seed beds daily and apply water if the surface of the soil becomes at all dry
* 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

**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
* Selective removal of diseased seedlings (crossing) is also common practice in nursery pest management

**Grafting and budding of fruit plants**

* Fruit seedlings or cuttings are normally grafted or budded onto a desirable rootstock under nursery condition
* With bare-root and leafless plants the risk of transporting diseases, nematodes and scales from nursery to field is decreased
* **Grafting tools;** Grafting knife, Secateurs, Grafting tape, Pruning saw, Wax, Sharpping stone, Sterilizing agent (alcohol), Plastic hate, Nail, Hammer and Labels

**Transplanting to permanent location**

* The final step in nursery production is transplanting seedlings to their permanent site     (field)
* The seedlings may be transplanted either with bare roots or with the soil ball containing     the roots
* Hardening involves a checking of growth resulting in the accumulation of carbohydrates, which before being 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
* Makes the plant better able to withstand adverse environmental conditions.

**CHAPTER FOUR**

**ESTABLISHMENT AND MANAGEMENT OF ORCHARD**

**Orchard** – is a place where different fruit crops are grown relatively at large scale

* It is a stand of fruit-bearing trees arranged and maintained to yield crops of maximum size and quality

**4.1. 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 condition
* Soil condition
* Vegetation (natural) and
* Previous cropping history
* Topography,
* Irrigation potential
* Infrastructure availability,
* Logistics and communications in relation to markets
* **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 *optimum* *temperature range*
* Within this range the two fundamental processes, photosynthesis and respiration, are proceeding, 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 varies 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:
* Fruit crops which produce their highest yields at a low temperature range (7 – 130C), e.g. Apple, Pear, Plum, Strawberry
* Fruit crops which produce their highest yields at a moderately high temperature range (l3 – 180C) e.g Peach, Nectarine grape, Blackberry, tree tomato and
* Fruit crops which produce their highest yield at a high temperature range (18 – 240C) e.g Banana, Citrus, Mango, Papaya, Fig, Date

**Rain**

* Fruit plants require adequate soil moisture throughout the growing season;
* however, there might be some critical stages
* A pattern of continual rains during the pollination period could result in poor crops How?
* Continual rains during the fruit harvesting period leads to problems, not only in harvesting operations but also in promoting various fruit disease (fungi, bacteria)
* Most fruit plants will not tolerate water around their roots for any length of time, as the water stops air penetration to the roots might be hindered

**Wind**

* **Wind** can be detrimental from several aspects. It can damage young, tender shoots and           can scar- bruise on young fruits
* Reduced bee activity during windy days in the pollination season can seriously reduce fruit set and yields
* So, how this problems can be monitored or corrected?

**Altitude**

* **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     0.6°C.

**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
* The ideal orchard soil should be deep at least 1.8m, well-drained, non saline, fertile, clay loam to a fine sandy loam

**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

**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

**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

**4.2. Land Preparation**

**The purposes of land preparation are to:**

* Level the land where needed; why we need level the area?
* Incorporate crop residues, green manure and cover crops; prepare and maintain a seedbed in good tilt; why?
* Help control weeds, diseases, and insects; How?
* Improve the physical condition of the soil, and
* Fruit crops may be established on new (virgin) and/or cultivated land first by clearing the residues and second level the area
* **Windbreaks***-* Wind can have a definite harmful effect on fruit production. Windbreaks must be used to decrease the wind velocity and fruit damage

**4.3. Planting System**

* Prior to ordering the planting trees, an orchard plan should be drawn on paper to show the location and many other aspects i.e field layout
* Different planting systems are used in fruits planting 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

**1. 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%

 **Merits and demerits:**

* Most commonly followed and simplest of all and easy to lay out.
* The possibility of cultural operations in two directions is the greatest advantage of this system.

 The major disadvantage of this system is that

* a lot of space in the center of each square is wasted.

**2. 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.

**3. 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.

**4. Triangular/Quincunx:** the same as square planting except that an additional plant is placed at           the center of each square called filler tree

* Generally, plant distance within and between rows depends on several factors.
* The major factors may be as described as follows:

 a. The ultimate tree size of the species and cultivar at maturity

 b. Soil fertility-

 c. The planned tree density*-*

**4.4. Digging holes for planting**

* Large holes 0.6 –1m in both width and depth are dug prior to planting
* Pile topsoil and subsoil separately
* Leave the soil for one month
* One month later refill the topsoil only
* Refill the hole with a mixture of 50% top soil and 50% well decomposed manure
* in soils where phosphorous is lacking add supper phosphate
* pile the soil a bit above the ground level
* when the soil settle (after one month) excavate the soil

**4.5. Irrigation**

Irrigation requirement depends on:

* Type of crop (two weeks deficit seriously affects banana while citrus is not affected by 2 dry months if it is not at bearing stage) and, extent of the deficit:
* **Good irrigation:** correct timing of application and supplying proper amount of water and distributing it uniformly

**When to irrigate?**

* Water balance in the soil – based on climatic data
* Leaf symptoms: wilting, rolling, etc. this may not work for some fruit crops, like citrus which draw water from the fruits
* Soil feel and physical condition (cracking, etc)

**Methods of Irrigation**

* The major types of irrigation systems are surface, sprinkler, drip and sub-surface irrigation and the choice is governed by:

Methods of delivery water (open ditch or underground pipe)

* Size of stream and duration of flow
* Topography and slope of the land
* Soil characteristics (infiltration rate and WHC)
* Quality of irrigation water
* Cost of irrigation water

**4.6. Mulching**

* Mulching is covering the soil surface by spreading layers of straw, leaves and other plant trash or plastic sheets.
* An ideal mulch is one that is readily penetrated by rain, maintains its form through the season

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

* Protect the soil from rain erosion
* Improve water infiltration; How?
* Conserve soil moisture; How?
* Enrich the soil with nutrients when and how?
* Encourage microorganisms living in the soil
* Reduce weed growth near cultivated plants

**4.7. Fertilization**

* The type and amount of nutrients required are a function of soil type, growing region and crop load
* The macro and micro nutrients may be required

**4.8. Training and pruning of fruit plants**

* Training: is a physical technique that controls the size, shape, and direction of plant growth.
* This can be:- orientation of plants in space
* providing support on which plants may grow
* may include twisting, fastening or bending of the plant to support structure;
* Pruning: is a judicious removal of plant parts often combined with training e.g. grape.
* Generally, the objective of changing the spatial form or size of a plant is:
* To improve its appearance or usefulness
* To establish a balance between vegetative and fruit bearing
* To increase efficiency of light utilization
* To facilitate orchard operation (spraying, weeding, picking, etc.
* To control diseases and pests – dense canopy favors pests and diseases
* To enhance productiveness of plants and the quality of the produce

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

**a. Heading back** consists of cutting back the terminal portion of a branch to a bud,

**b. Thinning out** is the complete removal of a branch to a lateral or main, that is, the entire twig,         cane, or shoot is removed

* 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°, why?
* The lower part of the slant should be above the base of the bud.

**4.9. Pollination Management**

* During the planting process the farmer should create the best conditions for the future pollination,

**4.10. Weed, Disease and Insect Management**

* At the early stages of field establishment weeds often cause greater losses than insects or plant diseases.
* 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 weed and insect pest include the following:

* Legislation: quarantine laws
* Sanitation: eradication, disinfection, rotation
* Resistance: use of resistance or tolerant cultivars
* Mechanical mean’s: hand picking, flaming, banding
* Biological means: predators and parasites
* Chemical means: spraying, dusting
* Integration: a combination of all

**CHAPTER FIVE**

**MAJOR FRUIT CROPS GROWN IN ETHIOPIA AND ELSEWHERE IN THE TROPICS AND SUB -TROPICS**

**1. Banana (*Musa spp)***

**Origin, distribution and use of banana**

* Banana is originated in South East Asia
* It is important in humid tropical lowlands, with year round fruit production.
* The fruit is a valuable source of carbohydrate and is higher in energy value than most fruits.
* It is source of some Vitamins (A, B1, B2 and C).
* Male buds are eaten as a vegetable in some parts of Asia (India and Malaysia).
* Male buds and pseudo stems are used as feed.

**Botany and morphology**

* It belongs to the family Musaceae and the genus musa and it is a tree-like herb, Perennial but mono carpic – a shoot flowers only once & dies after it has borne fruit.
* The plant is perennial, as the corm’s life is perpetuated by suckers.

**The Structure of Banana Plant**

* It is a tree like herb, perennial but mono carpic because a single sucker shoots flowers only once.

**1. Flower (inflorescence)** - has three parts

* Female- Found at proximal and the 1st 5 to 15 clusters which gives fruit
* Hermaphroditic – Fall early (after one or two days) and they don’t give fruits
* Male – Found at the distal part or lower end and they form abulbous “male bud” which is tightly packed with bracts.

**2. Fruit** – the banana fruit develops partinocarpically i.e. Without fertilization.

* A fruit cluster forms is generally called “hand” and a single fruit is called a “finger”. Bunch is a collection of hands
* A good bunch consists of 8 hands; each hand contains 15 fingers, and each finger with average weight of 150g.
* Fruit yield/ plant = number of hands/bunch X numb. of fingers/hand X weight of each finger

**3. Psedostem** – leaf overlapping

**4. Corm (true stem) -** found below ground and should be covered with soil in order to avoid          root drying and to make the plant stable. It also serves as the storage organ of the plant.

**5. Roots**

**Classification**

* In Musaceae family there are only two genera, viz., Ensete and Musa.
* The genus musa contains five sections which are:

1. Eumusa (2n=22) = The largest and most edible banana and most wide                                        spread

2. Rhodochlamys (n=11) = Used as ornamental purpose

 3. Callimusa (n=10)

 4. Australimusa (n=10) =Used as cooking vegetable

 5. Ignetimusa (n=14) = Source of fiber

* Eumusa (2n=22)
* Unlike other four sections, inflorescence hung down
* Emusa has two different wild species:
* Musa acuminata (A genome) – Dessert bananas
* Musa balbisiana (B genome) – Plantain
* *Musa accuminata* has three types of banana
* The first type had genome A- seedy, small fruits and are inedible
* The second type had genome AA-seedless fruits
* The third type had genome AAA-bigger seedless fruits
* The last two had edible fruits. These were the first bananas planted by man
* The fruits of *Musa balbisiana* has not consumed fresh. It is resistant to different diseases and drought.

**Cultivars**

* The cultivars of banana are derived from the two wild species
* Fifteen morphological characters have been identified to distinguish edible banana cultivars (i.e., between *Musa acuminata* and *M. balbisiana*

**Note;**

* For each character in w/c the cultivar agreed with wild *M. acuminate the score ‘1’is given.*
* For each character in which the cultivar agreed with wild *M. balbasiana* *the score ‘5’is given.*
* The scores range from 15 ( 1x15) for pure *M. acuminata*, to 75 (15 x 5) for pure *M. balbisiana*
* A cultivar would have a large score if it were derived from *M. balbisiana* and smaller if it were derived from *M. acuminata*
* The modern methods of classification for edible bananas was devised by Simmonds and Shepherd(1955)
* The classification proposed by these scientists is based on two things:
* On the relative contribution of the two species to constitution of the cultivar
* On the ploidy ( chromosome numbers)
* All banana taxonomists seem to agree that no single scientific name can be given to all edible bananas
* To avoid confusion , it is internationally accepted that all banana cultivars should be referred by
* Genus Musa followed by
* A code donating genome group and ploidy level followed by subgroup name (if any) followed by the popular name of the cultivar
* Example:
* Musa AAA (Cavendish subgroup) ‘Grand Nain’
* Musa BBB ‘Saba’
* Musa AAB(plaint sub group) ‘Horn’

**Banana cultivars**

* **Poyo** *-* a leading cultivar, comparatively resistant to transport damage.
* **Dwarf Cavendish** *-* better adapted to a cool climate than any other Cavendish cultivar.
* In recent years its popularity has been declining owing to its susceptibility to burrowing nematode and *cigar-end rot* disease.
* **Cavendish** *-* a tall growing strain of Cavendish, which has largely replaced the “Dwarf” in commercial plantations.
* **Ducasse** *-* locally called “Kenya” banana in Ethiopia
* In 2006 EIAR released four desert and four cooking bananas to different agro ecologies of the country;

**A. Desert Type:** Williams-1, Grand Nain, Robusta, Butuzua

**B. Cooking Type:** Caradaba , Kitawira , Nijiru , Matoke

**Ecological requirements**

* Banana is typical tropical crop

**Soils:** can grow at all type of soil.

* But deep, well drained, friable loamy soil with adequate organic matter content is ideal for banana cultivation

**Climate:**

* **Rain fall;** banana has high water demand because of its broad leaves. 2000-2500 mm evenly distributed average annual rain fall is considered satisfactory

**Effect of high water deficit**

* The leaf turned yellowish green and died.
* The growth of the plant is stunted and the fingers become short
* **Temperature -** 270c is optimum forbetter growth.
* If the temperature is <130c and >380c
* Banana cannot with stand frost and chilling injury occurs at <12 0c because the latex coagulates and translocation can be blocked

**Propagation**

* Banana is usually propagated asexually by using vegetative propagules: **suckers** & **corm** or **corm bits.**

**Banana propagation using suckers**

* Based on age there are four different types of suckers, such as:

**1. Pepper suckers**

* Very young suckers with scaly leaves
* Used for nursery establishment rather than transplanting
* Used also for planting during shortage of planting material

**2. Sword suckers**

* Have narrow leaves & broad rhizomes with good stored food
* The pseudo stem is broad at the base & gets narrower at the top

Points of consideration during sword sucker selection

**3. Water suckers-**Not that much important for planting b/c they result in less vigorous plants

**4. Maiden suckers-** Large suckers which passed sword suckers stage but not fruiting

* They are used for re – filling already established banana orchard

Suckers are the most commonly used methods

* Fruit earlier
* Give more hand per bunches and more finger per hand than started from corms

**Spacing and whole digging for planting**

* Spacing of 2.5x2.5m is sufficient to allow for mechanical cultivation in both directions (Ethiopia)
* Spacing of 2.5m between rows and 2m between plants is another alternative (cultivation in one direction)

**Procedures of planting suckers**

* Remove the stick marker
* place the sucker in the middle of the hole
* Return the top soil you had previously dug up
* Press down the soil firmly around the planted suckers.

**B. Banana propagation from corm bits**

* Split of corms can be used when suckers are not available

If the corm bits are going to be used for propagation, follow the following steps of preparation:

1. Select good suckers for planting which are 7 months old (prior to fruiting)

 2. Uproot and separate the corm from the pseudo stem by cutting 10 – 15 cm above the corm

 3. Remove the roots, trash and the soil from the corm using knife

 4. Peel the outer layer about 3mm depth and also remove damaged part of the corm using a               knife

 5. Wash the corm to remove trash and soil

 6. Split the corm in to seven bits & each bit should have at least one bud in the middle.

 7. Soak the corm bits in hot water 60oc for 20 minutes or nematicide or weevilicide solution            such as furdan for 12 hours ( for nematode protection)

 8. Store (dry) for 48 hrs in clean and shady areas

       9. Plant the corm bits by covering with 20 – 30 cm soil layer and with the corm eye facing              down ward

**Banana bunch and suckers management**

**1. Banana bunch management**

* The whole hanging inflorescence is a bunch.
* It contains about 8 hands at average.
* Each hands contains about 15 fingers each weight.

A. **Propping**; is supporting of a bearing banana plant in the direction of leaning.

* The lodging of banana plants particularly at maturity stage result in heavy loss.
* Two props, forming a triangle are better than one.

 B. **Dehanding**; is the removal of false hands ( last hands)

* It is usually an incomplete hand, not fit for export

**C. Deflowering**; is the removal of the dry flowers in 8-12days of bunch management

**D. Debelling**; is removal of the male bud at 15cm from the distal

**E. Bagging or bunch covering;** is cultural techniques used by planters, particularly where          export bananas are grown

**F. Earthling up**; protects the plant against wind damage. During the rainy to provide drainage &        to avoid water logging at the base of the plant

**G. Leaves removal**; pruning of surplus leaves are a common operation in banana production.

**2. Banana sucker management (desuckering)**

* Suckers are produced from the rhizome of banana.
* The number of suckers produced per clump varies depending on spp., soil fertility, climate etc.
* Removal of unwanted suckers is one of the most critical operations in banana

Only the three plants should be allowed to grow.

1. Mother plant; is the bearing banana plant
2. Daughter plant; is banana plant about to bear
3. Granddaughter plant; is young banana plant

 **Linear succession**

* Plants left standing in a straight line, the original spacing would soon be disrupted

**Diseases and other pests**

* *Bacterial wilt -*the organism attacks the roots and underground portions
* *Cigar-end rot* - The fungus infects the dry flower parts
* *Leaf spot -* It produces yellow and then necrotic leaf lesions
* *Nematodes* - Bananas suffer greatly from nematodes
* *Banana weevil* - this is a major insect pest which attacks banana and plantains

**Harvest and post-harvest handling**

* Maturity determination - Mature fruit is less angular and more rounded (“full”).
* From bloom to harvest it takes 80-95 days under good conditions and may extend up to 120 days under sub-optimal conditions (in subtropics it even lasts longer).
* **Ripening**
	+ - Banana is climacteric fruit
		- Local experiences indicate that temperature in the ripening room should be 19-240C
		- Plantains, unlike dessert bananas, are much starchier and can be eaten either ripe or unripe; they are cooked, fried or roasted

**2. PAPAYA (*Carica papaya* L*.)***

**Origin and Distribution**

* Papaya (*Carica papaya* L.) is the most important species of the 21 others found in genus Carica
* Common names for the group includes papaya, pawpaw, papayer (French), melonenbawm (German), lechosa (Spanish), mamao, mamoeiro (Portuguese), and mugua (Chinese).
* All Carica species are native to tropical America
* The major producers are Hawaii, Tropical Africa, the Philipines, India, Cylon and Malaya etc.
* Hawaii and Srilanka are the major producers for fresh market and Papain respectively
* In Ethiopia it is currently produced in home gardens and semi – commercial level by farmers as well as commercial level by state farms
* Many growers prefer papaya to other fruit crops due to its early bearing habit and ease of production practices (Jackson *et al.*, 1985; and IAR, 1991).

**Problems in papaya production**

a. Difficulty of obtaining true to type planting materials

b. Too tall after few years

c. Difficulty of identifying sex type of the plant until the plant flowers

**Composition and Use**

* Papaya fruit contains water, sugar, fat, protein and minerals. The table shows the composition of mature fruit.





* The seeds are also used for their medicinal value
* Seeds contain amino acids and faintly scented oil
* The juice facilitates digestion and so that it is preferable for older people
* Aykroyd (1951) ranks papaya 2nd to Mango as a source of vitamin A.
* The yellow pigment in the papaya is not carotene but carica xanthin

**Botany and Morphological features**

* Papaya belongs to the family Caricaceae
* Papaya is a large herbaceous plant, with a single, un branched and erect trunk that terminating with a crown of large leaves
* It is semi-woody and hollow
* The bark is smooth, grayish in color, with large, prominent leaf scars.
* When the stem is wounded thin milky sap oozes from the wound.
* The cluster of leaves at the apex and along the upper part of the stem makes up the foliage of the tree.
* The type of inflorescence depends up on the sex of the tree.
* In staminate trees, flowers are sessile (stalk less) and are produced in clusters on long pendulent racemes 60 – 90 cm long.
* The individual flower is tubular, with ten stamens in two series of five, attached to the throat of the corolla tube, and lacks a pistil.
* The hermaphrodite flower is between the two unisexual flower types and exhibits numerious deviations, depending on the season or age of the tree
* Roots grow down to 45 cm (it is shallow rooted).
* Even though the root system is very dense; roots are soft and can easily be damaged
* Fruits are fleshy berries, 7–60cm in length.
* Pistillate flowers give spherical fruits and that of hermaphrodite is pear - shaped, cylindrical or grooved.
* Papaya has small, rounded and dark green or brown seed that attached in 5 rows to interior wall of ovary.
* It has mucilaginous cover.

**Floral Biology**

The three types of papaya flower

**1. Female papaya flower-** Conical bud, Petals free, large ovary with, prominent stigma, No          stamens, **does not form fruit unless pollinated**

**2. Hermaphrodite papaya flower-** Cylindrical bud, Petals fused at base, Contains both ovary            and stamens self-fertile

**3. Male papaya flower-** Slender, Spoon shaped bud, Petals fused at base, Contains anthers but                           no ovary and cannot develop into fruit

* Sex expression in papaya is controlled by a single gene with three alleles which have a      pleiotropic effect.
* The sex homologues designated as: M1 for **male**, M2 for **hermaphrodite** and m for **female**.

**Mating System, Sex Variation and Expression in Papaya**

* There are two major sex forms in papaya.
* In **dioecious** types male and female are born on separate individuals but in hermaphrodite types both sexes found on the same individual.

**Sex in papaya is determined by three genetic factors:**

* **M1=**dominant for maleness
* **M2=**dominant for hermaphrodicity
* **M=**recessive for femaleness

The diploid homozygous dominant types are lethal and so that they doesn’t express themselves. So, we have:

* M1m = Male, which doesn’t bear fruit but dehisce pollen
* M2m = Hermaphrodite, which bear fruit
* Mm = Homozygous recessive female, which bear fruit
* The genotypes for sex are M1m for male, M2m for hermaphrodite and mm for female.
* The diploid homozygous dominant types (M1M1, M2M2 and M1M2) are lethal and so that they doesn’t express themselves.



Example

* M1m x mm = ?
* M2m x M2m = ? What will be the ratio for each sex?
* Fruits of females are rounded and that of hermaphrodites are long and pear shaped
* The main problem in papaya production is that the sex of the tree cannot be determined until they reach flowering
* A number of trials were made to determine the sex of seedlings before flowering.
* Dark brown seeds of medium size were conductive to pistillate flowers;
* whereas dark brown seeds of large size produced predominantly hermaphrodite plants.
* At very low temperatures (<120C) no or male (pistillite: reverted male) flowers are produced
* Male trees will produce a number of bisexual or even pistilate flowers.

**Cultivars/Varieties**

* A large number of papaya cultivars are found in cultivation.
* Bisexual
* Dioecious
* None of these is a true cultivar

**Solo**

* The major world cultivar because the size is suitable and the quality is high.
* It is hermaphrodite and the fruit has pear shape

**Ecological Requirement**

* Papaya is grown in the warm and humid climates of the tropics up to 1500 masl and in frost less sub-tropics approximately in between 320 N and 320 S.
* The minimum and maximum **temperatures** for tree survival are -10C and 440C respectively.
* The optimal believed to be between 25 and 380C. Plant growth is retarded in temperatures less than 150C.
* Papaya is an evergreen plant and it bears flowers or fruits for most part of the year
* Adequate drainage and soil aeration is important factors for successful papaya cultivation.
* Generally, a well-drained, permeable, rich in organic matter, sandy loam soil with pH of 6–7 is the best.
* Most tropical areas have well defined wet and dry seasons.
* The relative humidity should be about 60%.
* If irrigation is available to keep the soil moist, areas with low relative humidity are preferable.

**6. Pollination**

* Papaya flowers are pollinated by natural agents
* They may be wind-pollinated,

**Cultural practices**

**Propagation**

* Propagation is primarily from seed
* Due to non-branching growth habit of papaya, trees produce few cutting and propagation by cutting is therefore impractical in commercial operations.

**Seed Collection and preparation**

* The plants raised from seeds have a mixed inheritance, which makes them highly variable in performance
* If such seed is not readily available the grower should select seeds only from the best plant on the basis of vigour of the plant, shape and color of the fruit,
* Thickness of flesh, quality, yield and optimum spacing of the fruits on the stem
* Seeds should be obtained from hermaphrodite plants, which had been selfed or crossed with other hermaphrodite

**QQ. why we should get seeds from hermaphrodites?**

* Dioecious plants normally produce a 1:1 ratio of male and female plants, which will result in the production of four or five times as many male plants as, needed for pollination

**Potting, Sowing and Germination**

* Pots should be filled and compacted well with a mixture of topsoil, compost

**Fertilization**

* Papaya is very responsive to fertilizer application and yields can be significantly improved by proper fertilization
* Fertilizer rates and types are varying depending on soil nutrient status, climate and other factors.
* In MARC experimental fields two bucket of decomposed cattle manure is applied before planting. 128 and 218 grams of Urea and DAP respectively are applied per plant per year.

**Irrigation**

* It responds well to better water management. Adequate irrigation helps in rapid fruit development and also to obtain regular fruit yield.
* The plant is highly sensitive to water logging, hence, it is most important to prevent ‘wet feet’ in papaya irrigation
* In general irrigation to grown up plants is given once 7- 10 days.
* In areas where annual rain fall is <700mm, supplementary irrigation is required. 50 -75 mm water is required every 3-4 weeks
* Dioecious cultivars are fare better, unless moisture stress is severe.
* The double ring system of irrigation is better than the bed system, How and why this could be? What you think about this truth?
* As papayas are wind pollinated and overhead sprinkling reduces pollen dissemination and therefore is not recommended

**Harvest and Postharvest Handling**

* Harvest is simple when fruits can be reached by hand; as trees become taller,
* Mechanical damage during harvest shorten the shelf life, hence, care is needed.

**A**. **Anthracnose** (*Colletotrichum* spp*.*)

* Small, round, water socked area on ripening portion of fruits
* The spot enlarge rapidly and fruit start rotting
* Favored by wet weather condition

**B**. **Black spot (***Asperisporium caricae*),

* Affect both the leaves and fruits
* But not develop in fruit rot
* Leaf spots are grayish white, roughly circular and turn black
* Makes leaves to drop

**C**. **Powdery mildew** (*Sphaerotheca* spp.)

* White powder growth on the leaves
* Cause premature drop of leaves
* Cool and cloudy weather

**D. Papaya ring-spot virus**

* Yellowing and vein clearing in young leaves and sometimes severe blistering and leaf distortion.

**3. MANGO (*Mangifera indica*)**

* The most popular fruit ands has been called king of the fruits
* It belongs to family [Anacardiaceae](http://en.wikipedia.org/wiki/Anacardiaceae)
* Genus *Mangifera*.

**Composition and uses**

* Ripe fruits are consumed as fresh and fruits are processed and canned
* Edible portion of ripe fruit take up 60 - 75 % of the fruit
* A typical composition of the mesocarp is: 84 % water, 15 % sugar, 0.5 % protein.
* Unripe fruits are reach in starch, which is hydrolyzed to sugars during ripening.
* The fruit is an important source of vitamin A, fair in vitamin B and with varying quantities of vitamin C.
* The seeds contain 70 % carbohydrate, 10 % fat and 6 % protein
* Mango leaves are used to decorate the entrance of a household amongst Hindus.

**Botany and morphology**

* Mango has deep tap roots (provide anchorage for the tree) that can go as deep as 5 m down to the soil.
* There are shallow dense fibrous roots that take nutrients and moisture from the soil.
* After transplanting the seedling develops a good network of surface roots (feeding roots).
* Mango tree produces thousands of flowers on each inflorescence, the majority of which are male flowers.
* However, hermaphrodite (perfect flowers) flowers do also exist but smaller in number (1 - 36 %).
* Mango can be classified in to two groups, monoembryonic and polyembronic based on their mode of reproduction from seed

**Monoembryonic**

* Produce only one embryo(contain a single zygotic embryo(sexual embryo) and hence produce only one seedling per seed
* Sexual in origin and
* Do not breed true to type, so monoembronic type must be propagated vegetatively if one want to preserve their properties

**Polyembryonic**

* Contain two or more embryos of which one is usually zygotic , all other are nucellar
* Produce many seedlings from single seed
* Nucellar seedlings are preferred for propagation of mango rootstocks because of their uniformity

**4. Ecological Requirement**

**Temperature:**

* The optimum temperature for mango is 24 - 270C and the minimum and maximum temperatures are 100C and 420C respectively.

**Altitude**

* Mango in the tropics grows from sea level up to an elevation of about 1220 m, but it seldom bears at higher altitudes.
* It is naturally adapted to tropical low land between 25 0 N and S

**Rainfall**

* Mango needs dry period of at least 3 months for flower induction but younger trees require optimum moisture
* This helps the tree to accumulate sufficient carbohydrates which are conducive to flowering.
* A well distributed rain fall of 900 - 1000 mm in the main rainy season is adequate for successful production under rain-fed conditions
* For mango production distinct wet and dry seasons are essential
* What will happened in areas where there is rain for the year round, during mango production? Discuss this
* In areas which receive heavy rain-fall during most of the year, mango trees show profuse vegetative growth at the expense of fruiting
* Excessive rain-fall and high humidity is greatly reduced; How?

**Frost**

* The susceptibility of mango to frost varies with its age and state of growth.
* Young plants of four to five years in active growth are killed if the temperature falls below -1 to -2 oC.
* Some varieties are known to be more prone to frost injury than others.
* Older trees with less growth activity usually escape the damage at this range provided the duration of low temperature is not prolonged

**Wind**

* In regions subject to high wind velocities mango trees suffer in many ways, such as crop shedding or even by trees falling
* The establishment of wind breaks or shelters in such areas can minimize the loss to some extent

**Soils**

* Mango does not require much fertile soil, rather it grows best on marginal (poor) soils but drainage is a must because it cannot resist water logging
* Extremely fertile soils should be avoided because there will be only vegetative growth at the expense of fruiting
* Soil should be well drained and without a hard pan

A pH of 5.5 - 7.5 is preferred

* On deep fertile and well-drained soils rootstock seedlings grow faster
* In very sandy soils transplanting mango plants in balls of soil is difficult.

**Cultivars**

* **Mango cultivars fall in to two broad categories:**

**1. Indian types**

* They are monoembryonic (produce one seedling from a given seed), highly colored and fibreless
* Have distinct aromatic flavor
* Susceptible to anthracnose (*Colletotrichum glesporiodes*) which attacks both fruits and leaves.
* The most important in international market but they do not give true to type.
* The most important types for export

**2. Indochinese or Philippines cultivars**

* They are polyembryonic (many seedlings from a single seed).
* Fibrous and sweet tasting
* Fruits lack attractive coloration
* Up on ripening, fruits remain green or half green or a little bit reddish but do not turn yellow, orange or reddish (fruits remain green when ripe)
* Generally they are poor bearers
* Resistant to anthracnose and bacterial brown spot.
* Produce many embryos, asexual in origin and breed true to type
* Tommy Atkins, Kent and Kiett-are some of internationally known varieties
* In Ethiopia Apple mango (introduced from Kenya) and Sodere II cultivars

**6. Pollination**

* Flowers open early in the morning with maximum anthesis between 8 - 12 a.m
* Stigmas appear to be immediately receptive
* Nectar is secreted by the disc, the flowers are visited by insects (mainly flies and thrips) and pollination is mainly entomophilous
* Pollination is essential for fruit setting and the development of seed, even when all the embryos are apomictic
* Rain and high humidity at blossoming reduces pollination and fruit setting

**7. Cultural practices /crop husbandry**

 **Propagation**

* Mangoes can be propagated by seed and most of the world's mango trees are of seedling origin
* Except in the case of apomictic seedlings from poly-embryonic seeds, plants must be propagated vegetatively to produce clonal material true to type
* Seeds may be planted in nurseries
* They may also be planted direct at stake
* Stocks are also raised in this way and the seed for them should be selected from strong-rooted and vigorous cultivars
* They are best stored in charcoal for 100 days. Seeds are sometimes shelled (endocarp removed) and this hastens germination
* Removing the hard cover from the seed results in uniform and rapid germination and also straight stem and root will be acquired
* But this method is not recommended for large scale production because it is laborious (expensive), and risky (embryo may be destroyed)
* While sowing mango seeds, depth and position are important.
* Generally the depth should not be more than 5 cm
* As to the position, put always the convex side up ward. This is because of polarity
* Sowing can be done in containers, nursery beds and directly in the field. For good management and selection container is preferred
* The pots should be 30 cm deep and should have drainage holes at the bottom.
* If sowing is done on nursery beds, the bed should be prepared well
* Rotten manure is mixed with the soil and the soil should be relatively shallow
* Soil composition: forest + sand + compost in 2:1:2 ratio
* Germination is within a week time under favorable condition
* Germination of seed stones takes approximately 20 days for seed sown 5 cm deep
* Budding and grafting are the most popular vegetative propagation methods in mango
* Vegetative propagation by cuttings, layering and marcotting has not been very successful in mangoes
* No need of vegetative propagation for polyembryonic groups
* This is not always true and there is time when zygotic ones may be vigorous as compared to nucellar seedlings

**Planting**

* The spacing in the field is 8 -10 m.
* Spacing depends on cultivars because some cultivars have spreading canopy by nature and others do not
* Holes with size of 50 cm by 50 cm or 60 cm by 60 cm are prepared before planting
* Square planting system is used and the best time of planting is at the beginning of the rainy season
* Intercropping in the early years with vegetables, legumes and pineapples is often practiced

**Fertilization**

* Mangoes are not heavy feeders, but respond well to N fertilizer
* 700 g N/tree/year is applied and it be in split (350 g at a time)
* **Phosphorus** is applied during planting in the holes and in the later years it is applied when sign of deficiency is observed
* The amount for P is 400 g P2O5/tree/year
* The amount may vary from place to place depending on soil type and variety

**Irrigation**

* Although it is a highly drought tolerant crop, mango will respond to irrigation in low rain fall areas where annual precipitation is below 900 mm
* Due to its deep and well developed tap-root system, it is well adapted to withstand periods of prolonged drought
* For young trees once in two weeks interval during dry period
* For old trees irrigation is at flowering and fruit setting

**Harvesting and post-harvest handling**

* The time of development after fertilization to maturity of fruit is 2 - 5 months, depending on cv and temperature
* It took 3 - 7 years of juvenile period for seedling trees to give the first harvest
* Some cultivars in addition to the main fruiting season, set a few fruits throughout the year
* Seedling mangoes take longer to come in to bearing.
* Yield depends on the cultivar and environmental conditions
* On average a seedling tree may live for about 100 years and a grafted tree for about 80 years

**Harvesting**

* Fruits are picked when they change color (green to yellow green)
* For export purpose they are picked while they are still green (but reach full maturity - 12 % TSS, specific gravity of 1.01 to 1.02 and the ability to withstand a pressure of 1.75 to 2 kg/m2)
* Some fruits drop (sign of harvesting) and abscission follows
* Harvesting should be done by cutting the stalk of the fruit instead of picking
* Mango fruits have got latex which oozes out from pedicel or fruit stalk and must be

**Grading:**

* After harvesting fruits are graded based on size, color and maturity.
* The biggest fruits get the first grade and secure highest market

**Waxing**

* The fruit should be covered by wax to reduce moisture loss for long distance transportation

**Disinfecting**

* Fruits are dipped in to ethylene-bromide to protect them from insects and other micro-organisms
* Benomyl solution is used against anthracnose as it is a serious problem after harvest
* wiped out to avoid rotting

**Storage**

* Storage temperature of 7 - 10oC is common for most tropical fruits to avoid chilling injury, will keep fruits for 2 - 4 weeks but it varies from cultivar to cultivar
* Long transport it is better if the humidity is 85-90%

**9. Major diseases**

 **A. Anthracnose, (*Colltotrichum glesporiodes***)

* Is the most serious and wide spread disease of mangoes, particularly in moist climates
* It causes leaf-spot, wither-tip of young twigs, blossom-blight and fruit rot
* Control is possible by copper fungicides and application is before the flowers open

**B. Powdery mildew (Oidium mangifera)**

* Causes losses to flowers and young fruits
* Its symptoms is white powdery on leaves, tender stems, flowers and fruits
* Results in flower abortion and fruit drop
* Control methods are dusting with sulphur karathane (5 g/ 10 liter of water)

**C. Mango-hopper or jassid, (*Idiocerus spp*.)**

* Is the most serious pest of mango blossoms
* Fruit flies and *Dacus spp*., attack mangoes by laying eggs in mature fruits
* Control is possible by the destruction of fallen infected fruits.
* Strict quarantine measures should also be adopted against the entry of fruit-flies.
* Mango-weevils, (Cryptorrhynchus spp.) which damage the seeds
* Mangoes are also attacked by thrips, scale insects and mealy-bugs

**Subtropical and Temperate Fruits Crops Production and Management**

* Temperate fruit trees grown in the medium-altitude areas and left without attention develop long
* However, at altitudes higher than approx. 1,800 m, temperatures can be low enough to induce seasonal growth
* As a result, the trees are harmed by the prolonged rest
* Effective fruit production requires general knowledge of fruit husbandry such as:-
* nutrition,
* propagation,
* pruning and training,
* effects of climate and
* crop protection as well as
* specific cultivation techniques for each fruit

**4.** **Avocado (*Persea americana*)**

**Origin and Distribution**

* It is rapidly becoming more important in world horticulture
* Avocado is native to Central America especially Mexico and Guatemala
* **Mexico**, Chile, and the **United States** rank as the top three world producers of avocado
* Avocado was introduced by **missionaries** (around Dilla and Ghimb areas), by **individuals** (Hirna area), by **foreigners** (around Wando Genet area),
* In Ethiopia avocado fruit is cultivated either densely of sparsely in whole Sidamo and Gede-o zones ,
* some parts of Borena, Jimma, lllu-ababor, Kaffa, Sheka, Bench - Maji Zones, some parts of East Wellega
* Moreover, in Ethiopia avocado farms are found at Zway, Tibilla, Bebeka and Tepi state farms

**Composition and use**

* The fruits are rich in fat, proteins, and minerals but low in carbohydrates content and can be recommended as high energy for diabetics
* Avocado is a nutritious fruit, containing 15 - 30 % oil, similar in composition to olive oil, different vitamins (eleven vitamins) (vit A, B6 , B12, K, C, E, Folacin, Niacin etc...) (fourteen )minerals
* Avocado is a **"complete food"** in terms of protein, containing 9 essential amino acids although not in proportions
* It can almost substitute butter and meat and it is called in many countries as **"poor man's butter".**
* Further it has several uses; as a natural cosmetic, with advantage in rapid skin penetration, and as a superior natural sun screen.

**Medicinal value**

* Avocados are mainly used fresh in salads.
* They have a high fat content combining well with acidic fruits and vegetables, such as citrus, pineapples and tomatoes, or with acid dressings
* The avocado is high in **mono-saturates** and the oil content of avocados is second only to olives
* Consequently avocado is also used to supply the fat content for ice cream and sherbets and processed into cooking oil as well as margarines **(a butter substitute)**
* It is known in preventing from many diseases (namely: Beriberi, anemia and for people on low Sodium diets, high blood pressures and some kidney disorders
* Avocados can help to **lower cholesterol** and aid in **blood circulation**.
* It is very high in fats but these are **monounsaturated** oleic oils which act as an antioxidant and block artery-destroying toxicity, or cholesterol

**Botany**

* It belongs to the family **Lauracea** and genus **Persea**.
* Three ecological races (subspecies or botanical varieties) are known
* Mexican = sub tropical
* Guatemalan = semi tropical
* The West India = tropical

**Vegetation & Fruit**

* It an evergreen tree which reach up to 10 to 15 m height
* The wood is soft so branches break easily
* Avocado trees are **shallow-rooted** and the leaves are **arranged in spirals,** coming out in flushes.

**Leaves**

* the leaves of West Indian varieties are scentless, while Guatemalan types are rarely     anise-scented and have medicinal use
* The leaves of Mexican types have a pronounced anise scent when crushed.
* The leaves are **high in oils** and **slow to compost** and may collect in mounds beneath trees

**Fruit**

* Avocado fruit is a one seeded berry. In shape the fruit is usually pyriform to oval and round and varies in colour from green, to yellow-green
* The buttery flesh **(mesocarp)** is greenish yellow to bright yellow to creamish when ripe. Each panicle will produce only one to three fruit

**Flowers**

* The flower is complete but it behaves in unique way.

**The Flower and Its Behavior**

**Flower Function**

* Avocado flowers **are perfect**, bearing functional male and female parts
* Most such plant species readily self-pollinate, i.e., pollen from a given flower can fertilize the egg of that flower
* However, the avocado flower performs in such a way that self-pollination is highly unlikely within a given flower and is difficult within a given tree or even a given cultivar
* In fact, if as few as 1% of the flowers mature fruit, the crop may still be too heavy for the tree
* This is because each cultivar is functionally male one part of the day and functionally female another part of the day
* Protogynouse, diurnally synchronous dichogamy i.e. each flower open two times and closed in between in the first time function as female and the second time as a male
* Avocado flowers were dichogamous, i.e., they first have a distinctive female period with receptive stigma and
* A subsequent male period when the stigma is generally considered no longer receptive and the anthers dehisce to expose pollen
* Flower opening is synchronous, i.e., flowers open and close in near unison throughout a tree
* Therefore, intelligent breeding requires a clear knowledge of the unusual functioning, which can only be understood in terms of the structure

**A and B flower types**

* Avocado flowers appear before the first seasonal growth. Flowers are perfect but are only receptive to pollen at a specific time which is dependent on type
* **Type (A)** are receptive to pollen in the morning but shed pollen the following afternoon.
* **Type (B)** are receptive to pollen in the afternoon but shed pollen the following morning.
* Nearly all avocado cultivars (and seedlings) fall clearly into 1 of 2 contrasted categories conventionally designated **A and B**

**Female flower**

* **A-type** cultivars have their first or female opening in the morning, perhaps about 9 AM to noon.
* The second or male opening is the afternoon of the following day, perhaps noon to 6 PM. So, for a particular flower, the total time span from first opening to final closing is about 24 hours
* The first time an avocado flower opens, the pistil is alone in the center, with the stamens and other flower parts close together at an angle of 45° or more away from the pistil
* At the end of the opening period, the perianth re closes tightly and stays closed overnight
* The stigma is then receptive to pollen so that the egg can be fertilized.
* The flower is female in function but it is not functionally male since the stamen valves remain tightly shut and no pollen is or can be shed
* The flower remains open in this female stage for perhaps a couple of hours, then closes for the rest of the day and that night.

**Male flower**

* The second opening the next day exposes an easily recognizable functional male flower
* The nine stamens are noticeably larger and somewhat longer than on the previous day;
* the inner three stamens stand erect adjacent to the pistil,
* while the outer six stand out at an angle of about 45°.
* B-type cultivars first open in the afternoon, perhaps 1 to 4 PM.
* The second opening is the following morning, perhaps 8 AM to 1 PM, so the total time span is below 24 hours
* The flower opens for the second and last time on the next day, but it is then functionally male

**Daily synchronization**

* Flowering persists for several weeks, the length of time required being dependent upon cultivar and climatic conditions
* The time required for opening and closing is short, usually taking substantially less than 1 hr
* Flower opening is synchronous, i.e., flowers open and close in near unison throughout a tree
* Hass' is an example of an A flower type, 'Fuerte' of a B. There may be a thousand 'Hass' trees,
* All of them will open at about the same time and close at about the same time like a million reasonably accurate clocks.
* Similarly, each afternoon perhaps a million flowers will have their second or male opening, and will do so again about synchronously
* Hence, opportunity for self-pollination will be very limited
* A thousand adjoining 'Fuerte' trees would behave the same way, but with the times of the male and female stages reversed



Every morning A pistil can be fertilized by B pollen, while during the afternoon B pistil                   are ready to receive A pollen

**Consequences of Avocado Flower Behavior**

**Cross-pollination**

* Is the inevitable result of the flower functioning described above.
* In our examples, 'Fuerte' is functionally male, i.e., is shedding pollen over the entire period that 'Hass' is functionally female, i.e., its pistils are receptive and must be pollinated if fruit is to set.
* The converse is true of 'Fuerte' set. Thus, A and B trees provide complementary cross-pollination.

**Genetic variability within the individual**

* Is the inevitable result of cross-pollination.
* This means that any individual seedling or cultivar has different hereditary options at many different gene locations and
* can be expected to produce an almost unlimited assortment of sex cells for the next generation
* Hence, avocados are more like humans than they are like tomatoes or
* other plants in which pure breeding lines produce any number of seedlings genetically identical to the parent

**Self-pollination**

* Our analysis of flower functioning showed self-pollination to be difficult, but it is by no means impossible.
* There is a little variability in time of flower opening or closing due to differences in location on tree (in terms of sun or wind exposure *etc.),*
* Adjoining trees of the same cultivar would be expected to have this variability
* Finally, weather changes can affect the timing of some flowers more than others.
* It is usually possible to obtain ample breeding progenies from self-fertilization.

**Environmental Effects**

* The synchronously dichogamous nature of dianthesis in avocado flowers is extremely sensitive to environmental conditions.
* With optimum climatic conditions, daily flower openings are uniform and remarkably predictable.
* Fog at night and rainy weather affect regularity and continuity and sequence of bloom.“
* Under low-temperature conditions, both female and male openings in type A cultivars may be retarded so much that they become reversed
* Thus, instead of morning-opening flowers being female and afternoon-opening flowers being male, the reverse is observed, i.e Type B behaviour

**Avocado Races/Varieties/cultivars**

* There are literally hundreds of different varieties of avocado, generally sub-divided in to three distinct horticultural races
* Some commercial avocado cultivars Furete, Hass, Nabal, Bacon, Pinkerton, Ettinger are popular known cultivars available in the world.
* They differed in fruit size, oil content and their areas of adaptation
* In general, hybrids between the West Indian and Guatemalan races are well adapted to lowland and middle elevation tropical conditions.
* Guatemalan-Mexican hybrids are well adapted to highland tropical areas and to subtropical areas with a Mediterranean-type climate

**Ethiopian context (Local lines)**

* The avocado cultivated today in Ethiopia except by state farms are originally introduced from unknown areas
* Small fruit sized trees are Mexican race that adapt to medium to high land areas
* Large fruit size trees are difficult to trace to either Guatemalan or West Indian
* Some commercial avocado cultivars Furete, Hass, Nabal, Bacon, Pinkerton, Ettinger are popular known cultivars available at Jimma.
* Their properties are shown in table bellow:-

Table 1: General properties of avocado races



Table 2: Avocado cultivars and their properties

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cultivar  | Flower type  | Races  | Oil content(%)  | Cold resistance  | Maturity season  |
| Furete  |  B  | Mex. x Guat.  | 18  | -2 to -30c  | Mar-May  |
| Hass  |  A  | Guat.  | 25  | -2 to -30c  | Oct.-April  |
| Bacon  |  B  | Mex. x Guat.  | 18  | very sensitive  | May-Oct.  |
| Nabal  |  A  | Guat.  | 16  | -1 to -20c  | Dec.-May  |
| Pinkerton  |    |    | 24  | -1 to -20c  |  -  |
| Ettinger  |    |    |    |    | April-May  |

**Ecological requirements: avocado**

* Produced practically in tropical and subtropical with latitude of 40 o N and S
* Avocados have wide adaptability
* However the three best known races each requires specific climate as a result of adapting to original environment
* They are also limited ability to adapt & are very sensitive to unfavorable condition which lead to low, irregular or no yield

**Temperature**

* West Indian varieties grow will in warm humid climates with monsoon rains and optimum temperature of 25-28oC.
* This race is susceptible to frost however, and temperatures below 1.5oC damage the plant.
* The Mexican races possess greater winter cooling tolerance and are able to be grown at a minimum of minus 4oC to -5oC without suffering any damage
* The Guatemalan is adaptable to a cool tropical climate but is less tolerant of low temperatures
* For both the Guatemalan and Mexican race (types A & B), temperatures of 15-20oC are considered optimum

**Sunlight**

* Avocadoes are only productive in full sunlight; therefore it is important that plants are not planted in the shade, nor are allowed to get crowed, for example failing to carry out a planting plan**.**

**Frost & Wind**

* Frost protection is important because as well as causing leave, wood and flower damage it can blacken the internal cells of the fruit making it inedible
* leave, wood and flower damage it can blacken the internal cells of the fruit making it inedible.
* The Mexican type is good for colder regions because of this very factor
* The following should be undertaken to avoid both frost and wind damage;
* Provide shelter from wind and frost. Use shelter belts & frost covers.
* Plant above a slope for air drainage

**Water**

* Most cultivars are sensitive to water stress and excess moisture caused by poor drainage.
* Irrigation should be provided during the dry season, but avoid over watering
* Yield is reduced when the irrigation water is highly saline
* Among the tree races West Indian cultivars are more adaptable to summer rains
* while the Mexican cultivars possess greater tolerance to water stress and low humidity.

**Soil**

* Sandy loam is best for avocado cultivation as it can’t tolerate heavy soil with water logging situations,
* Avocadoes can however, tolerate both alkaline and acidic soils. Sandy loam is best

**The West Indian race**

* Is best adapted to lowland tropical conditions.
* It is tolerant of high temperature and humidity, soil salinity, high soil pH and diseases such as anthracnose, cercospora spot and scab.
* These races are very sensitive to drought stress, doesn't tolerate frost well and minimum temperature for foliage is 1.5 0C decrease yield
* Large fruits with a dark green and sometimes rough skin
* Originated in highland areas and is well adapted to cool conditions (highlands) with a Mediterranean-type climate
* It is the coldest hardy of the races of avocado, but is poorly adapted to conditions of high humidity and temperature
* These require lower temperature than other races
* Mature trees can with stand temperature of 5 to -4 0C without damage to foliage or wood flowers,
* These races require a lower humidity than West Indian race but better fruit set
* It is intolerant of calcareous soils and high soil salinity

**The Guatemalan race**

* Is intermediate between the West Indian and the Mexican races in adaptation to soil and climate conditions.
* These require a cool, tropical climate without any extreme temperature or humidity
* The tree can with stand only slight frost, down to -20C, but the flowers are sensitive to frost (example Hass)

**Pollination**

* Since avocados are out breeding, put bee hives in avocado orchards for sufficient and reliable pollination
* It is not recommended to plant avocado in close proximity to citrus orchards

**Cultural Practices /Crop Husbandry**

**Propagation**

* It can be propagated either by seed or vegetative means
* The drawbacks that seedlings have are :
* Yield poorly, especially during the first few seasons;
* They also start bearing after 8-10 years of planting
* Propagation by seed used to establish small family orchards
* Seeds must be collected from only healthy root stock cultivars and vigorous mother trees & fruits which are mature & sound
* Seeds loose viability with in 20 days after pulp is removed under ordinary condition
* Seeds are planted in nursery beds with the flat basal end down just deep enough to cover the tips. Sep to Oct.,
* Before planting, extracted seeds should be treated in hot water (49-520C) for 30 minutes

**Planting**

* Avocado trees brought from a nursery should already have been hardened
* Plant the trees as soon as best after receiving them
* Plant A and B type that produce flower at a time
* The closest initial tree spacing 4-6 m x 4-6 m that is economically feasible but, can depends on:-
* Vigour of the rootstock
* Cultivars natural growth habit(spreading and erect etc)
* Soil conditions(type and depth) , climates and others
* In many countries 400-800 trees/ha of grafted avocados are planted

**Irrigation**

* Irrigation of young trees is important to ensure a uniform stand
* Avocados are sensitive to moisture stress
* Poorly drained soils also predispose the avocado tree to water borne fungal disease

**Fertilization**

* It is important not to fertilize young, transplanted avocado trees soon
* Since the avocado tree is very sensitive to root damage

**Harvesting and post-harvest handling**

* While on the tree the fruit remain hard, avocados only became soft and edible after they have been harvested
* It is not easy to decide the right harvesting time by the skin colur
* Immature fruit don't become soft of the skin creases after 7 to 10 days
* One common method of whether a crop is ready for harvesting is:-
* To pick a few fruits when they are apparently mature and then leave them to ripen in a warm place

**Pests**

* Avocados are highly susceptible to root rot caused by *Phytopthora cinnamomi* in the soil

 **CITRUS FRUITS**

 **Origin and distribution**

* Citrus is a collective name for different many species and their crosses under the **genus citrus** and family **Rutaceae**.
* **Origin: South East Asia**
* **Major producers are**: Brazil (**1st** ), USA (**2nd** ) and China (**3rd** )

**Uses of citrus fruits**

* One of the major group of fruits grown in tropical and subtropical regions of the world
* World citrus production increased significantly in the last few decades
* The industry has prominent place in the international market both for fresh and processed products
* because citrus fruits are mainly used as
* Good source of vitamin “C” and energy- source of food
* In 100gm juice: 12% sugar, 50 mg vitamin c and 1% citric acid found
* Source of citric acid (lemon and lime 6-8% citric acid).
* For extraction of essential oils from the peel or flowers.
* Raw material for agro-industries
* Sources of incomes
* Major citrus growing regions in Ethiopia, tropical lowland areas
* Commercial varieties to Ethiopia were introduced from South Africa and Italy,(1920) and California(1967)
* There are five nursery in Ethiopia : Errer Gota, Nura Era, Zway, Merti and Gibe
* Citrus trees are found throughout the country
* Northern Ethiopia - Azezo, Bahr Dar, Mersa, Cheffa Shoa Robit
* Central Ethiopia - Abadir, Awara Melka, Kessem, Nura Era, Merti, Tibila, Degaga, Wonji, Ellen, and Ziwai
* Eastern Ethiopia - Dire Dawa, Errer Gota
* Southern Ethiopia - Arba Minch, Awassa, Billate, Gojeb, Mizan Teferi
* Western Ethiopia – Guder, Bako

**Botany**

* Citrus has two subgenera
* **Eucitrus** and
* **Papeda**
* **Papeda** is inedible because of the acrid oil in juice sacks which is bitter.
* **Eucitrus**: is the edible citrus and has 10 spp out of which eight spp. are cultivated



**Hybrids**

* E.g. Tangor = Mandarine X Sour orange
* Tangelo = Mandarine X Grape fruit
* Lemonime = Lemon X Lime

**General morphology of citrus**

* The trees are small having angled twigs which become cylindrical latter (round)
* They have spines at each leaf axils; sometimes they are lacking (older branches).
* Have unifoliate leaves usually with winged petioles.
* The leaves are thick, leathery with translucent oil cues.
* Flowers are axillaries, solitary or clustered, cymes and white in colour
* Fruit are special types of berry called hesperidum
* Filled with juice sacs
* Covered by a white spongy tissue (albedo) and a peel(flavedo) with numerous oil glands
* Turning yellow or orange at full maturity

**NOTE: Identification of citrus**

* Color and petiole wing are important for diagnosis (identification purpose). E.g.
* Leaf colour: lemon has pale green leaves but others have deep green leaf colour.
* Petiole wings are missing in lemon and sour orange, grape fruit and shaddock have broad petiole wings but others have narrow petiole wings.
* Flowers are white in most spp but in lemon and citron purplish on the outer side.
* Fruit size: the largest fruit is shaddock followed by grape fruit but lime is the smallest
* The peel is loose and easily detached from the segments in mandarin but adheres in other species

**Ecological Requirement for all citrus**

* Citrus growing in the belt of 20 - 400 N and S of the equator
* In tropics citrus is grown 0 - 1800 m a.s.l.
* citrus species have a wide range of adaptability
* Different spp. may require different environmental conditions
* Naval group prefers slightly cooler conditions
* Valencias will tolerate fluctuating cold and warm weather

**Temperature (To)**

* The optimum temperature for citrus growth is 25-30oC
* Growth ceases at temperature< 13oC or >42oC

**Rail fall**

* Good citrus production requires a well distributed sufficient amount of RF
* Grows well in 1150mm-1500mm per annum
* If there are 3 dry months there should be supplementary irrigation
* During blooming ( flowering) and fruit set period require regular application

**Soil**

* Citrus tree will grow in a wide variety of soil
* good soil would have clay, sand and silt in appropriately proportion

**Fertility**

* Chemical properties of a soil can be changed relatively inexpensively with fertilization, manuring and liming
* If pH<5, the soil becomes acidic and citrus roots will not grow, nutrients are leached out and some nutrients become toxic. e.g.: Cu, Fe, Al, Mn
* If pH>6 some nutrients fixed. E.g Fe, zn and the plant shows deficiency for these nutrients

**Citrus crops husbandry/cultural requirement**

**Propagation of citrus**

* Citrus cultivars can be propagated by seed or vegetative means
* Vegetative propagation methods includes

**Cutting**

* A portions of the stem, root or leaf is cut from the parents plant
* Cuttings should be made from well matured wood of one or two seasons growth
* A cutting should have at least 3 - 4 well matured buds (about 15 cm long)

**Pest management**

* Citrus is susceptible to many diseases

**Bacterial diseases**

* Profitable production of citrus is limited by disease caused by bacteria, fungi and viruses
* Most of citrus disease are caused by bacteria( citrus canker, citrus variegated chlorosis etc)

**Viral diseases**

* The most destructive disease of citrus
* The major citrus virus disease that limit successful citrus productions are
* **Citrus tristeza virus(CTV**) ( quick decline)
* Causes loss of millions of trees on sour oranges rootstock in Brazils
* **Psorosis or scaly bark disease**
* Bark lesions which only develop six to 10 years after infections

Transmitted during propagation

**Fungal diseases**

* Numerous citrus disease are caused by fungi
* They causes fruit blemishes and post harvest fruit decays
* Several fungal disorder also affect the fruits and canopy
* Of disease affecting the tree Phythophtora, gummosis(poor drainage) leaf and fruit spots and foot rot
* ***The most devastating nature of this disease:***
* Premature abscission of young fruits and leaves
* Development of spots and lesions, which make fruits unmarketable
* A yield loss of 50-100% is very common
* 65 % yield loss in Ethiopia

**Control measures**

* Using sanitary measures such as removing infested fruits and leaves and eliminating dead branches by punning

**Insects**

* There are a number of insects which attack citrus
* Fruit flies
* Mediterranean fruit fly
* Lay egg just under the epidermis of the fruits and larvae tunnels in to the fruits

**Scale insects**

* Most serious
* Red scales, soft brown scales , soft green scales and wax scales

**Aphids**

* Sucking insects which damage growth and transmitted tristeza

**Fruit piercing moth**

* Feed on mature fruits, cause fruits to rot and drop prematurely

**Nematodes**

* Burrowing nematodes, citrus nematodes
* Difficult to control so selection of nematode free site and free nursery stock

**Pruning of Citrus**

* Pruning which is very little at early stage helps to develop branched trees.
* In latter stage pruning is only to remove:
* Diseased and dead branches.
* Branches touching the ground.
* Inward growing branches.
* Suckers from the root stock should be removed regularly

**Harvesting of citrus**

* Citrus harvested manually for fresh market, rather than mechanical harvesting

**Maturity determination of citrus fruits**

* **Colour:-** Colour change mostly from green to light green or yellow but it is not reliable for low land tropics because of no chilling temperature for normal colour development
* **TSS**: when 10-16%.
* **% of H20** soluble citric acid (≤1%).
* **% juice**: at 50%

**Time of harvesting of citrus**

* Harvesting of citrus should not be during humidity, but it should be during dry weather. Because humidity can cause:
* Mold development
* Fruit bruising

**Storage**

* Citrus have large storage life relatively because of
* They are non-climacteric ( with low respiration rate at maturity)
* They have leathery peel surrounding the edible portions
* Citrus can be stored in cold store. E.g Sweet orange and mandarin for 2 mouths at 0-4oc

**Citrus fruits of major economic importance in Ethiopia**

**1. Sweet orange** – cultivars of sweet orange that are economically important in Ethiopia

**2. Valencia**

* widely grown cultivar worldwide
* Has high fruit quality
* Very suitable for processing
* Late maturing cultivars

3. **Washington Naval**

* Seedless cultivars because functional pollen is lacking and viable ovule is rare
* Has narrow range of adaptation unlike Valencia
* Early maturing as compared to Valencia

**4. Hamlin**

* Grown in climate of relatively high temperature and humidity
* Early maturing cultivars

**5. Pineapple**

* Juice quality and color of fruits is good
* Recent introduction to Ethiopia
* Have high tendency to alternate bearing
* Mid season cultivars

**6. Mandarin**

* Easily peeled as compared to other citrus which give popularity
* More perishable than other fruits

**7. Satsuma**

* Earliest mandarin cultivars
* Have narrow range of adaptations
* The fruit is puffy(skin loose fitting to juice portion of fruit)
* Easley damaged and weak in flavor

**8. Fairchild**

* Early cultivar of high quality
* It is hybrid of Clementine mandarin and Orlando tangelo
* It is reported as lower yield in Ethiopia as compared to Fremont and Dancy

**9. Lime**

* The principal use of lime is processing(juice and peel oil)

**10. Grape fruits**

* Is not popular in Ethiopia
* There are two important grapefruits cultivar grown in Ethiopia

**a. Redblush**

* The fruits stores well and is excellent quality
* Not suitable for processing because the pigments is not retained
* It mature earlier than marsh

**b. Marsh**

* Medium sized fruits
* It is very juicy and has good flavor
* It is very productive

**Lemon**

* The demand for lemon is not so great as for orange and mandarin
* Very sensitive to heat and cold and thrives in some locations

**Apple (*Malus domestica*)**

* Apples are fruits that are native to temperate regions. Apples are among “top deciduous fruits”.
* Apples are grown for several values;
* Income generation
* Dietary and health values
* Diversification of farmers’ production
* Soil and water conservation purposes
* Foreign currency earning at national levels
* Global apple production is dominated by China.
* It produces about 41 % of world apple production.
* United States, France, Turkey, Italy, Germany, Argentina, Japan , Chile etc
* Apples can be adapted to the cool highlands of the tropics ranging 2000-3000 masl.
* Introduction of apple trees in to Ethiopia was started some decades ago.
* Trees as ages of about forty years are reported to exist in Tigray at **Dabat**.
* The trees were also introduced in to **Chencha** area in the early 1970th by missionaries

**Apple production in the tropics has many challenges**

* Chilling condition is lacking
* Delayed foliation (failure of trees to produce leaves properly in the spring)
* Death of the terminal buds (usually)
* Poor yield and possibly the death of the tree

**How to overcome the low chilling problem in the tropics?**

* Selection of cultivars with low chilling requirements
* Careful site selection
* The use of rest breaking treatments
* Mineral oils, dinitro compounds, KNO3, thiourea, cyanamides, and mixtures of cytokinin and gibberellins

**Botany and Morphology**

* Apples are among temperate fruits.
* It is one of the most widely cultivated tree fruits and belongs to the family ofRosaceae genera Malus.
* The genus Malus consists of 15 primary species.
* *Malus domestics-Apple*
* *Malus sylvestrus* and
* *Malus baccata*
* The tree is small and deciduous trees and rarely evergreen trees.
* It can range in height from 2-8 meters depending on varieties and rootstock used
* Apple tree is extremely composed of the central leader , main and sub laterials and so forth.
* **Central** **leader** -the shoot that make central framework
* **Crotch**-angle between branch and trunk
* **Main** **lateral** -side shoot growing out of central leader
* **Sub** **lateral** -shoot growing from main lateral
* **Spur** -a short branch which bears fruit buds
* **Spure fruit bud -**large rounded bud which produce blossom and the fruit
* **Growth bud -**small flat bud which produce the shoot
* **Water shoot -** soft shoot which is unbranched and unfruitfull

**Varieties/Cultivars**

* More than 3,000 different kinds or varieties of apple are grown in the world.
* They are different in shape, size, color, flavor and other qualities
* Popular cultivars in east Africa include Anna, Golden Dorset and winter banana. Anna and Princesa

**Environmental factors**

**Latitudes**

* Mostly confined to the middle temperate latitudes ranging 300 to 500 in both hemisphere

**Elevation**

* Higher elevation are colder than low once

**Dormance**

* Denote the visibly inactive state

**Type of dormance**

* **Ecododormance(quescence)-** External condtions unfaribale to growth
* **Paradormance**(correlative inhibition)- Inhibitory infulence of another plant parts at Fruiting stage
* **Endodormancy**(rest)- Internal pysiological blocks

**Chilling**

* Temrature situation that enables a plant to break dormance

**Propagation**

* There are two basic methods of producing a fruit tree: by **using seed (sexual)** or **vegetatively (asexual)**

**Planting**

* A year old trees with lateral branches are prefered to trees with out laterals

**Fruit Thinning**

* Ensures satisfactory development of color, shape and size of the apples that remain on the tree
* Otherwise decreases formation of flower buds for the following year and causes trees to produce a crop only every other year.
* The earlier hand thinning is completed, the more effective it will be in achieving the desired results

**Diseases and insects**

* Powdery mildew (shoot, Leaf, Flowers)
* Scab lesion (leaf, fruit)
* Apple (Malus domestica) Family: Rosaceae Long term perennial, deciduous fruit Apple production in the tropics …..challenges..?
* chilling condition is lacking delayed foliation (failure of trees to produce leaves properly in the spring) flowering over an abnormally long period sporadic leaf production death of the terminal buds (usually) poor yield and
* possibly the death of the tree
* How to overcome the low chilling problem in the tropics? cultivar selection (low chilling requiring) Chilling temperature: 0-10 oC (2 – 7 oC)
* careful site selection (up land, cooler areas)
* the use of rest breaking treatments -mineral oils, dinitro compounds, KNO3, thiourea, cyanamides, and
* mixtures of cytokinin and gibberellins.
* rest avoidance (training of branches nearly horizontally => facilitates axillary buds growth)

**Apple varieties & pollination management**

* Self fruitful- self pollinated
* Partially self fruitful - require cross pollination (or benefited significantly by cross pollination)
* Self unfruitful (sterile) -require cross pollination
* Pollenizer cultivar Requirements for achieving effective pollination:
* Compatibility to the main variety
* Flowering and bearing at the same time or at the same age as the main variety Adaptable to the agro-climate of the region
* Regular and profusely flowering (giving good amount of viable pollen)
* Yield fruit of commercial value

**Approaches in introducing pollenizer into orchards:**

* Inter-planting along with choice variety
* Determination of proportion…? Planting plans, spacing, and management of pollenizers (e.g., proper pruning).
* Top working (in established orchard)
* Grafting
* Budding
* Rootstocks The most important traits to consider are: growth control
* Dwarfing
* Semi-dwarfing
* Invigorating
* tolerance to soil and climatic variables,
* resistance to insects and diseases
* precocity and yield efficiency, and
* tree anchorage
* Vigorous varieties on:
* MM111 produce trees semi-dwarf in size, or 70 to 80 %
* the size of those on seedling rootstocks MM106 rootstock produce trees 65 to 75 %
* the size of those on seedling rootstock M-7A rootstock produce trees 55 to 65 %
* the size of those on seedling rootstock M-26 rootstock produce trees 50 to 60 %
* the size of those on seedling rootstock M-9 are 35 to 45 %
* the size of those on seedling rootstock. M-27 are 25% or less the size of these same varieties on seedling rootstocks.
* Sunlight vs tree size & tree shape
* The development of new bearing wood requires moderate, but not excessive vigour and good light exposure
* The limiting factor in the productivity of an apple tree is the shade it casts upon itself

Three distinct light zones within an apple tree

* The zone which receives less than 30% full sunlight is less fruit & produces smaller fruits of unsatisfactory colour

How to improve exposure to sunlight?

* Cone or pyramid shape (more exposure to sun)
* Open-center tree (Less exposure to sun)

**Training and pruning**

* Correct training & pruning are essential for:
* Early production
* Sustained high yields
* Optimum fruit quality, and
* Efficient management

**Objectives of training:**

* To develop a strong structural framework capable of heavy crops in future years =>the framework should facilitate the development and maintenance of optimum tree shape
* To produce trees that would be easy to manage in later years