DEBREMARKOS UNIVERSITY

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
DEPARTMENT OF HORTICULTURE

Subtropical and Temperate Fruit Crops Production and Management

HAND OUT FOR

Compiled by: Yebirzaf Y.

Updated by: Yohannes G.

April, 2020
Debre Markos, Ethiopia

CHAPTER ONE

INTRODUCTION

At the end of this section students will be able to:

- Identify the importance of fruits (nutritional, medicinal, economical)
- Describe the present status and future potentials of fruit production in Ethiopia
- Identify problems associated with fruit production in Ethiopia

Subtropical fruits: Fruits are plants in the sub-tropical group, do not withstand freezing temperatures, and many do not grow well if temperatures drop below 10°C. These plants do not require cold temperature exposure for either vegetative growth or flower initiation. Because Subtropical climates are often characterized by hot summers and mild winters with infrequent frost. This region is located between the tropics at latitude 23.5° and temperate zones north and south of the Equator. Avocado, Blue Java, bananas, White Sapote, Mango, Jaboticaba and low-chill stone are some of the examples of subtropical fruits.

Temperate fruits: Fruit crops that are grown in the temperate- regions of the northern and southern hemispheres. These plants withstand very cold winter temperatures and do in fact require winter chilling for good productivity. Grape, peach, strawberry, nut, walnut, apple and plum are among temperate fruits that are grown in Ethiopia.

Effective fruit production requires general knowledge of fruit crop growing such as nutrition, propagation, pruning and training, effects of climate and crop protection as well as specific cultivation techniques for each fruit. Fully revised and expanded to include organic fruit production.

1.1 Importance of fruit production in Ethiopia

Activity 1.1 Discuss the importance of fruit crops?
Activity 1.2 State the present status, challenges and opportunities of fruit crops 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: For family consumption; Provide employments for family; Used for exports; For local market (for income generation); Wind break, soil conservation, firewood, animal feed, shade, ornamental purpose, etc.

1.2 Present Status of Fruit Production in Ethiopia

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

known for many of them.

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 (i.e., with no or little input of improved and up to-date agricultural technologies). As a result, not only yield per hectare is low but also fruit quality is poor. Therefore, fruit coming from this sector is mainly used for domestic consumption (self-consumption and local market).

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

Evidently, a number of indigenous, edible, fruit plant species are found in various parts of the country. Despite their importance, ecological adaptation and genetic resources, no attention has been given either to domesticate or even protect them in their natural habitat so far. Since these fruits are naturally found in forests, the ever-increasing population pressure and relentless clearance of forest inevitably endanger such endemic species. There is an urgent need for means and strategies to protect and exploit them to the best of our advantage.

1.3 Problems Associated with Fruit Production in Ethiopia

Absence of broad genetic base- As aforementioned most economically important fruit species are exotic (introduced into the Ethiopian agricultural system). The number of cultivars in use is very limited (i.e., the genetic resource bases for further improvement is narrow). Generally, the existing materials in the farmers' hands are of unknown origin, inferior in yield and quality; and prone to pests.

Poor knowledge of the society about the nutritional value of fruits- Until recent time, the nutritional advantage of fruits was not well known, and hardly included in daily diets. Even today, the large mass of Ethiopians living in rural areas still considers fruit as a luxury rather than necessity food stuff.

Lack of improved planting material and production technology - Even though there is an increase in fruit production in the last few decades as a result of the increase in local and export demands, so far there is a lack of improved planting material and production technologies that can help to satisfy the ever-increasing demand of growers.

Lack of appropriate post-harvest technology - Generally speaking, fruits are fleshy and/or juicy, and are easily perishable. Aside from problems related to harvesting, postharvest losses of fruits are high due to lack of proper handling and transportation facilities.

Disease and insect pest problem - Various diseases and insect pests are known to cause serious damage to cultivated fruits. This problem is threatening low input farmers to the extent of

discouraging maintenance of established crops or further expansion. For instance, at present leaf and fruit spot of citrus *(Phaeollamularia angolensis)* is found to be a very threatening (catastrophic) disease to citrus production especially in south western parts of Ethiopia.

Marketing - In various fruit growing areas of Ethiopia, it has been observed that the harvesting period of most fruits coincide and so local markets often get saturated. This often leads to a drop-in price of fresh fruits and so lowers the moral of farmers and discourages better management or further expansion. Because of their perishable nature and bulkiness fruits will lose their quality with time and need to be sold within a short period of time. This, therefore, calls for planning and establishing appropriate postharvest handling facilities in the fruit marketing system.

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

b) Market

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

CHAPTER TWO: Citrus fruit production and management

At the end of this section students will be able to:

- Explain origin and distribution of Citrus
- Analyse nutritional use and composition of Citrus
- Describe botany and morphology of Citrus
- Discuss Citrus cultivars
- Select and identify ecological requirements of Citrus
- Recognize pollination of Citrus
- Demonstrate cultural practice of Citrus
- Discuss harvesting and post-harvest handling of Citrus
- Identify pests and diseases of Citrus

1. Citrus Fruits

1. Origin and distribution

- ❖ Citrus is a collective name for different and 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)

2. 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.
  - ☞ Cattle feeds are produced from the pulp and molasses (used as a binding agent in compound animal feeds, and also added to silage).
  - ☞ Raw material for agro-industries
  - ☞ Sources of incomes

3. Major citrus growing regions in Ethiopia

- o Commercial varieties to Ethiopia were introduced from South Africa and Italy, (1920) and California (1967)
- o There are five nurseries in Ethiopia: Errer Gota, Nura Era, Zway, Merti and Gibe
- o Citrus trees are found throughout the country
  - ▪ Northern Ethiopia - Azezo, Bahir 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

4. **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.

Botanical Name	**Common Name**
1. *Citrus sinensis*	Sweet orange
2. *Citrus aurantifolia*	Lime (lomi)

3. *Citrus limon* Lemon (Fernj lomi).
4. *Citrus aurantium* Soure orange/ bitter orange
5. *Citrus reticulata* Mandarin/ tangerine
6. *Citrus paradis* Grape fruit
7. *Citrus Medica* Citron
8. *Citrus grandis* Shaddock (pummelo)

- ❖ Shaddock is the largest of all above mentioned.

- 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). For example,
  - ☞ 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.

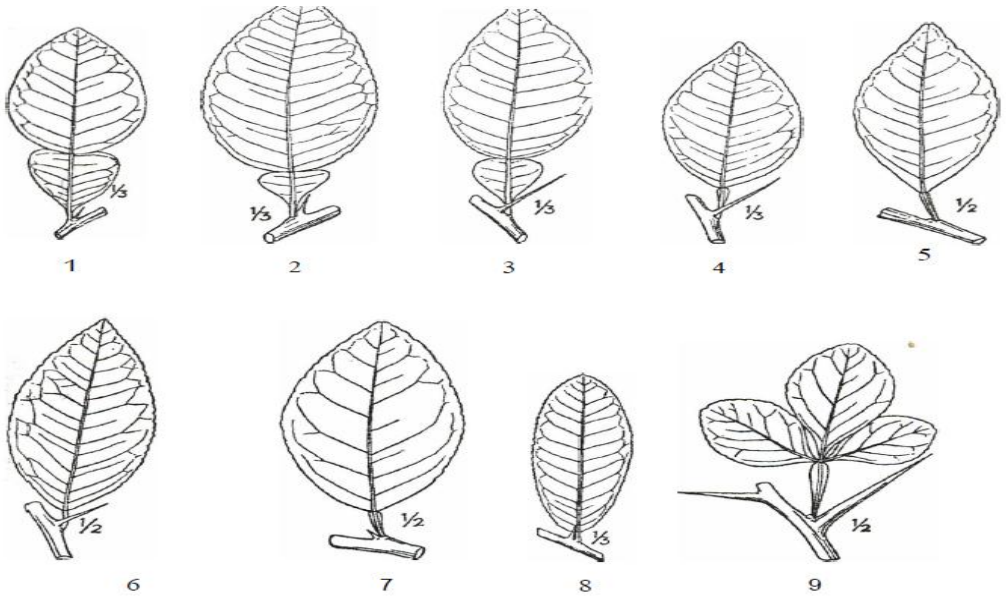


Figure 1. Leaves of different citrus plants and their relative (poncirus trifoliata): (1) pumelo (2) grapefruit (3) sour orange (4) sweet orange (5) mandarin (6) lemon (7) lime (8) citron (9) trifoliate orange. Adapted from: Hume, H. H. (1951)

5. Ecological Requirement for all citrus

Climate, soil and water are the chief environmental factors influencing the growth and development of citrus.

Climate is one of the most important factors affecting the profitability of a citrus orchard /industry. Temperature, rainfall and wind are the most important components of the climate that affect citrus production. Extremely hot or extremely cold temperatures are damaging to citrus. Frost could damage trees by injuring flowers, young leaves, and fruit.

The optimal temperature for growth of citrus is between 25° and 30°c. A higher or lower temperature than optimum range diminishes growth of the plants and growth ceases at a temperature of $l3^0$e. High temperature injury occurs at temperature above 42°C and is most severe during flowering or if cool temperatures are followed by hot. An apparent damage is deflowering and defoliation. Yet, citrus trees can withstand more extreme temperatures (up to about 50^0C) fairly well and down to the freezing point or slightly below it. High temperatures are harmful for two reasons: Respiration and transpiration continue at a high rate, while photosynthesis decreases sharply; and Pigmentation of fruit does not take place; on the contrary, colored fruit may re-green,

For good citrus production, trees will require a well distributed sufficient amount of rainfall or irrigation water. Where dry seasons occur, planning for irrigation is required. Water requirements vary according to climate and soils from as little as 450mm to as much as 2700mm per year (Rice et al., 1994).

Wind can cause serious damage to citrus trees and fruit. Hot dry winds will often scorch trees by drying young leaves. Winds of high velocities will scar fruits & cause fruit drop, break branches and in the worst case can uproot the trees. Where wind is a problem, windbreaks can be effective in reducing the velocity below damaging levels.

Citrus trees will grow in a wide variety of soils but they grow best on medium textured and moderately deep, well drained and fertile soils which are not high in soluble salts. The best pH for citrus soils ranges from 5 to 6. In soil which is too acidic, citrus roots do not grow well and nutrients are leached out, and some elements may even become toxic (e.g., Cu, Fe, AI, Mn). At a pH above 6, fixation of nutrients (especially zinc and iron) will take place and trees develop deficiency symptoms. A low pH associated problems can be corrected by liming the soil.

6. Citrus crops husbandry/cultural requirement

Citrus cultivars can be propagated by seed or vegetative means. There are literally thousands of citrus cultivars. Thanks to polyembryony and vegetative propagation the great majority of them are well-identified and established clones. With the exception of Mexican lime, commercial production employs scion cultivars budded onto a desirable root-stock.

The kind of rootstock used can have a profound effect on the results obtained throughout the life of the plantation. The choice of rootstock is, therefore highly critical; and a number of factors, particularly the disease situation and soil conditions, have to be considered. Spacing within the orchard depends largely on the scion and rootstock combination. As a general guideline, oranges, mandarins (tangerines) and grapefruit are spaced 7-9 m apart and lemons 6-8 m apart. Limes can be planted 5m apart. Spacing presently used in Ethiopia is indicated in Table 5-1.

Table 1 Recommended spacing for some citrus trees in Ethiopia

Type of fruit/cultivar	Spacing between rows and plants	Plant population/ha
Orange	8x4m	313
Mandarin	7 x 3.5m	408
Grapefruit	9 x 4.5m	247
Lemon	8 x 8m	156
Mexican lime	8x8m	156
Bearss lime	5.5 x 5.5m	331

Citrus trees respond vigorously to high levels of soil fertility although they are also highly sensitive to excess soluble salts in the soil; therefore fertilizer must be used with good judgment.

Normally citrus trees require regular application of nitrogenous fertilizers following planting. P, K, and minor elements should be applied only when deficiency symptoms are observed or when soils are known to be deficient. Nutrient deficiencies are best determined by leaf analysis. N should be applied according to the following formula (Jackson et al., 1985): l00g of N/tree/tree age (year/annum), up to a maximum of 2000g/tree/annum.

Thus, a tree in the first year after planting should receive l00g of N. This is equivalent to about 200g of urea (46% N), or to about 500g of ammonium sulphate (20.5%N). In the second year the application would be 200g of N per tree, and so on until the maximum quantity of 2kg of N per

tree is reached.

Ammonium sulphate ($(NH_4)_2S0_4$) is preferred to be used in slightly acid or alkaline soils. Fertilizer should be applied by broadcasting, over the area of the root zone followed by the mixing of the surface soil. However, at the early stage ring application can have a better effect.

When soils are known to be deficient in P or K, or when trees show deficiency symptoms of these elements, P and K may be applied according to the following formula: 25 g of P/tree/tree age/annum, up to a maximum of 250g/tree/annum.

The annual application rate of N should be divided into two equal parts, the first half being applied at the time when the main growth flush is starting and the second about three months after flowering, when the fruits are swelling. If P and K fertilizers are used, the whole amount should be mixed and added together with the first half of N. Additional amounts of fertilizer must be applied to inter-planted crops (if any). During the first year after planting, the annual nitrogen application may be divided into monthly or bimonthly applications.

Disease and Pest management

Citrus are susceptible to many diseases. Perhaps, the most serious are those caused by virus and virus- like organisms. These are transmitted by aphids, phyllids and other sucking insects as well as by vegetative propagation from infected trees. Control is therefore by correct propagation practices (using virus free propagules) and by controlling the insect vectors.

Tristeza (quick decline) occurs in conjunction with certain rootstock/scion combinations. Where the virus is present, sour orange should not be used as a rootstock. In this case, rough lemon, sweet orange, or cleopatra mandarin can be used as a rootstock. Symptoms of tristeza (viral disease) are rapid yellowing and death of foliage accompanied by branch dieback and eventually death.

Psorosis or scaly bark disease can be identified by bark lesions which only develop six to ten years after infection. Since psorosis is transmitted almost entirely by propagation from infected trees the disease can be largely avoided by careful propagation practices.

Citrus greening disease is a serious problem in middle altitude areas. It is transmitted by the citrus psyllid and by propagation from infected trees. The mycoplasma- like causal organism is heat- sensitive and so the citrus psyllid is not a serious problem in hot areas thus this disease is never severe in hot lowland areas. Symptoms include blotchy mottling of the leaves which resemble zinc deficiency, abnormally upright twiggy trees, fruit drop, sour fruit and a failure of fruit to colour properly upon ripening. Control is difficult and expensive but the disease can be prevented by controlling psyllids through sprays and insecticidal soil drenches. Infected trees can be cured by pressure trunk injections of tetracycline hydrochloride, although this is expensive.

In soils which are poorly drained, forms of gummosis and root and crown rots may be a problem. Prevention is by growing the citrus spp. in well- drained areas, not planting too

deeply, and using sour or trifoliate orange rootstocks where drainage is inadequate.

L*eaf and fruit spot of citrus* *(Phaeoramularia angolensis, syn. Cercospora angolensis).*The leaf and fruit spot of citrus attacks fruits, young twigs and leaves of citrus trees. In Ethiopia it was first observed at Bebeka state farm (situated at southern part of the country), and within a very short period of time, it spread to the wet regions of the south and south west parts of the country including Bebeka, Mizan, Metu, Jimma, Lemmu, Gibe, Wolkite and most parts of Sidamo. All over the country, the disease has become a threat to citrus production and currently it has reached epidemic level. The economic losses of the outbreak have resulted from direct fruit damage and premature leaf fall. The disease has become so drastic that, in some areas, farmers were forced to uproot citrus trees and replace them with other crop. Control of this disease may be achieved by using sanitary measures such as removing infested fruits and leaves; and eliminating dead branches and twigs by pruning operations so as to reduce inoculum density of the causative agent (fungus).

Among the most serious insect pests scales including red scale, soft brown scale, soft green scale and wax scale. Many species of fruit flies such as the Mediterranean fruit fly are damaging. Mites especially citrus red mite, thrips, aphids (especially black citrus aphid and brown citrus aphid) can reduce yield. The false codling moth, fruit- piercing moths and citrus psyilid make up the remainder of the serious pests.

Fruit flies lay eggs just under the epidermis of the fruits and larvae tunnel into fruit. Control of fruit flies is by destruction of infected fruit and removal of host plants from around the orchard.

Aphids are sucking insects which damage new growth and transmit tristeza virus. As with scale insects, ant control is the first step in controlling aphids.

False codling moths lay eggs on the fruit and larvae burrow inward causing the decay and collapse of tissue.

Adult fruit - piercing moths feed on mature fruits of citrus by inserting their mouth parts into the fruit. Secondary infection usually occurs which may cause fruits to rot and drop prematurely. Control is difficult.

Orange dog this caterpillar can do extensive damage to young trees and in citrus nurseries, where its feeding can result in the complete defoliation of a plant.

The *citrus psyllid* is a serious pest in the cooler areas of the tropics. Its feeding causes galls development on leaves and it also transmits citrus greening disease.

Over 15 species of nematodes attack citrus (Rice et al., 1994), the most serious of which are the ***burrowing nematode*** *and* the ***citrus nematode***. Control is difficult, so the orchard site should be tested for nematode prior to planting. Citrus should not be replanted where it has grown previously, and only nematode-free nursery stock should be used.

Weed should be controlled in an area 2m in diameter around the base of each tree. Weed control can be accomplished through cultivation or herbicides. After the weeds have been killed, a thick mulch will prevent new weed growth and will also conserve moisture. The area' between rows is

best grassed and mowed so that erosion is minimized.

Citrus require little **pruning**. Early tipping of main branches may be required to develop a balanced tree form. In later stages of growth, only branches which touch the ground should be removed, otherwise lower branches should be allowed to remain to protect the trunk from sunscald. Other pruning consists of removing diseased or crossed branches and removing vigorous suckers which occasionally grow up through the center of the tree or from below the graft union.

Maturity of citrus fruit is indicated by color changes in the rind. In cool tropical areas good color will develop. However, in the lowland tropics fruits may remain green at maturity. Though the lack of coloring decreases the attractiveness of the fruit, flavor is unaffected. If **degreening,** is desired, fruit can be treated with ethylene after harvest to destroy the chlorophyll in the rind and allow the underlying color to show.

Citrus fruits are harvested by clipping or pulling fruit from the tree Mandarins, lemons and limes are clipped while others are pulled with a slight twisting motion. Fruit should be handled carefully to prevent bruising.

After picking, fruit should be graded, washed and kept as cool as possible until consumed or sold. Damaged fruit should be discarded or used immediately. Ideal storage temperature is between 4 and 6°C.

Citrus fruits of major economic importance in Ethiopia

I. Sweet orange *(Citrus sinensis (L) Osbeck)*

Sweet orange is a highly polyembroyonic species. The fruit is sub-globose to oval in shape, orange colored, tight skinned, with a solid central core. It is sweet and flesh color is usually orange. The following are cultivars of sweet orange that are economically important in Ethiopia:

a. Valencia

This is the most widely grown cultivar worldwide. Apart from its high fruit quality, it has a wide range of climatic adaptation. It is a late cultivar, that is, a period of a-year or more may elapse between flowering and fruit maturation in the temperate zones.

In Ethiopia, commercial planting should be undertaken in the altitude range of 1,000 to 1,600m if fruit of high quality is to be expected. Valencia is very suitable for processing.

Nucellar budlines (clones obtained through the process of apomixis/nucellar embryony) of 'Valencia' exist: *'Cutter', 'Frost', 'Olinda'* and *'Campbell'*. It should therefore be propagated from the indicated budlines.

b. Washington Navel

This cultivar is seedless because functional pollen is lacking and viable ovules are rare. It has large fruit (spherical to ellipsoid) with thick rind. Sometimes, there is secondary growth (navel) that protrudes at one end of the fruit. Unlike Valencia, it has a narrow range of adaptation and is early maturing (as compared to Valencia). Washington Navel is less vigorous than other sweet orange

cultivars and poorly adapted to the humid tropics, semi-tropics, or intense desert heat. In Ethiopia its optimum range for planting probably lies between 1,500 to 1,800m. It is used primarily as a table fruit (eaten in the fresh form). The juice develops bitterness in storing and is thus unfit (less suitable) for processing.

c. Hamlin

It is an important early maturing cultivar. The fruit tends to be small unless grown in climates of relatively high temperature and humidity. However, it is not recommended for planting in the hotter part of the Valencia range.

In the tropics, it is probably best adapted to altitudes of 1,000 to 1,300m in areas where humidity is reasonably high.

d. Pineapple

This is a mid-season cultivar which has recently been introduced to Ethiopia. Both juice quality and color of the fruit are reported to be excellent.

II. Mandarin *(Citrus eticulata Blanco)*

Mandirin is a highly polyembryonic species. The fruits are medium sized, globose, sweet in taste, segments easily separable, loose skinned, orange in color.

It is generally recognized that mandarins have a wider range of adaptation than most of the sweet orange cultivars. In Ethiopia mandarins produce better color than oranges in warm climates. However, the fruit is more fibrous and of less desirable color compared to fruit grown in cooler climates. Unlike oranges, mandarins:

1. are liable to attack by fruit piercing moth and birds;
2. cannot be held for long on the trees after maturity without serious deterioration of quality;
3. have high losses from handling and transport damage.

Nevertheless, mandarins are very popular with consumers. Their popularity as "easy peelers" is increasing on overseas markets.

To secure good fruit set, mandarins in general, often require cross pollination and thus provision should be made for this in planning a new farm. Mandarins are more perishable than other- citrus, therefore,' in order to prevent heavy post-harvest crop losses improvements should be made in harvesting and handling methods.

III. Lime *(Citrus aurantifolia (L) Swingle)*

Lime is a highly polyembryonic species with smooth fruit surface, greenish-yellow in color and thin-skinned. The fruit core is solid at maturity, flesh greenish in color, and juice highly acidic.

The principal use of lime is processing (juice and peel oil), though considerable quantities are also marketed as fresh fruit. There are two natural groups: acid (sour) limes, and acidless (sweet) limes.

The two important cultivars of an acid limes in world production are described below.

*The "**West Indian**", "**Mexican**" or **Key lime:*** It is round, small-fruited (but is of superior quality aroma) moderately seedy and highly polyembryonic; it has a thin, smooth rind, greenish flesh and a citric acid content ranging from 7 to 8%. The fruit drops from the tree when mature. Even though no yield trials have been carried out, in Ethiopia there are several commercial plantings which have given good results (for example at Awara-Melka). Although this cultivar is susceptible to tristeza, it is usually grown from unbudded plant material (seedlings), as a satisfactory rootstock is unknown. However, in Ethiopia it is grown on Macrophylla rootstock.

*"**Tahiti**", "**Persian**" or **Bearss seedless**:* The fruit is larger than the 'West Indian' and is seedless but the juice is of lower quality. It can be grown in cooler climates than Mexican which requires rather high temperatures.

In Ethiopia, this cultivar is grown on Rough lemon stock. Even though yields obtained are promising, heavy losses of fruit have occurred through a physiological disorder known as *stylar end breakdown* which causes brown rot of the fruit. For this reason the cultivar is not recommended for commercial planting at present.

IV. **Grapefruit *(Citrus paradisi Macf)***

Grapefruit is a monoembryonic species with large-sized fruit. The fruit is subglobose to pyriform in shape (having the form of a pear) with thick and spongy rind. It is sweet and moderately juicy.

Grapefruit is not very popular in Ethiopia. However, there is a small market for fresh fruit of which the major consumers are foreigners. Seemingly there are opportunities for promoting consumption by natives and developing juice production.

Two groups of grapefruit are known: the pigmented and the white cultivars. In both groups seedy and seedless cultivars exist. In general seedy cultivars mature earlier than seedless ones; the former takes about eight months in favorable conditions, but over a year if there is insufficient heat.

There are two economically important grapefruit cultivars grown in Ethiopia:

*"**Redblush**"* In Ethiopia, this cultivar is grown on Sour orange and Troyer citrange rootstocks. The fruit stores well and is of excellent quality. Unlike "Marsh" it is unsuitable for processing because the pigment is not retained. It matures earlier than "Marsh".

*"**Marsh**"* This cultivar has medium-sized fruit, flattened to spherical in shape, with few or no seeds. It is very juicy, has a good flavor, and holds unusually well on the tree and ships and stores well. It is very productive and has a high heat requirement. Generally the fruit is better-suited for juice production than the red-fleshed cultivars.

High temperature is necessary for the production of grapefruit of high quality. The highest altitude limit for commercial planting in Ethiopia is probably in the region of 1,200m.

V. Lemon *(Citrus limon (L.) Burnt)*

Lemon is a weakly polyembryonic species with the fruit surface smooth, light yellow and core

solid.

The demand for lemons is not so great as for orange and mandarin. Lemon is very sensitive to heat and cold and thrives only in coastal locations with a Mediterranean- type climate. In Ethiopia, it has been observed that many mature lemon trees on various citrus farms appear unhealthy (suspected to be infected with "greening" disease), Until the root cause of this problem is identified, it would be safer to confine new commercial plantings of lemons to an altitude lower than 800m, where symptoms of greening and presence of the insect vector have not been observed.

Lemons are not eaten as fresh fruits, but are widely used in the preparation of lemonade, squashes and for culinary and confectionery purposes as a flavoring and garnish. They are used in cosmetics and for the production of lemon oil, citric acid and pectin. Rough lemons are used extensively as root-stocks for sweet oranges, grapefruits and mandarins. Lemons are less important than limes in the tropics, but they are extensively used in temperate countries.

"Eureka", ***"Lisbon"*** and ***"Villafranca"*** are the most widely grown cultivars of lemon. In the past much citrus have been grown from seeds, but it is now customary to propagate them by budding. Due to the presence of zygotic embryos, cultivars do not reproduce true-to-type seed. Nucellar embryos produce seedlings of the same genetic constitution as buddings from the same tree but they tend to be rather more vigorous, more thorny, and are slower to come into bearing. Rootstocks, however, are grown from seeds. Seeds should be obtained from good, fully matured fruits growing on vigorous, adult, healthy trees.

5. Harvest and postharvest handling

I. Harvesting Method: Citrus is hand harvested, whether processed or marketed fresh. Mechanical harvesters have been used for processed fruit in Florida and are increasing in popularity due to high labor costs and lack of labor availability.

II. Postharvest Handling: For fresh fruit, standard packing line operations are used (in order): dumping, culling, washing, brushing, waxing, drying, grading (human), sizing, and boxing. For processed fruit, growers are paid for "lbs-solids" or sugar content, based on juice analysis. Harvested fruits are culled for rot, and remaining fruit is washed prior to juicing. Juice is extracted by inserting a cylindrical strainer in the center of the fruit and compressing the fruit hydraulically. Extracted juice contains some pulp and oils, which are separated from the juice by centrifugation and screening. Juice is pooled into lots of various colors and sugar levels; some mixing is done to produce uniform product. Sales of frozen concentrate have been outpaced by single-strength juice products in recent years, due to the superior flavor of the latter.

III. Storage: Citrus may be stored for periods of up to 1-2 months at low temperatures (32-40°F). Chilling injury is common in grapefruit, lemons, and limes when stored below 50°F, but rare in oranges and tangerines. A unique aspect of citrus is the ability to store fruit on the tree. Fruit may reach minimum maturity standards in early winter, but since they are non-climacteric, they ripen slowly and will not soften or abscise for periods up to several months.

CHAPTER 3. Avocado (Persea americana) fruit production and management

1. Origin and Distribution

The avocado, a relatively new crop, is rapidly becoming more important in world horticulture. Avocado is native to Central America especially Mexico and Guatemala. In Central America and the West Indies, the fruit has been used as food for centuries. Mexico, Chile, and the United States rank as the top three world producers of avocado. Mexico is easily the largest producer, supplying over one third of the world's total production and over 40 percent of the world's exports. Avocado was introduced by missionaries (around Dilla and Ghimb areas), by individuals (Hirna area), by foreigners (around Wando Genet area), Ethiopian state farms (introduced six commercial cultivars), and by farmers from one areas to another contributing to the current wide distribution and diversity today it covers. In Ethiopia avocado fruit is cultivated either densely of sparsely in whole Sidamo and Gede-o zones , some parts of Borena, Jimma, lllu-ababor, Kafficho-Shekacho, Bench - Maji Zones, some parts of East Wellega and in other parts of Ethiopia avocado trees are found sporadically, that show the widest potential fruit, as compared to other tropical fruits. Moreover, in Ethiopia avocado farms are found at Zwai, Tibilla, Bebeka and Tepi state farms.

2. 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, B^6 , B^{12}, K, C, E, Folacin, Niacin etc...) (fourteen)minerals. The refined oil confer distinct health benefits: It is unusually light, so it mixes well with other foods. It has a mild, delicate flavour enhances and brings out the flavor off other foods instead of dominating them. It with stands high cooking T^0 before breakdown i.e about 25 ^{0}C, much higher than olive oils.

The calorific value is exceptionally high, 123 - 387 gm cal/100gm edible avocado but the sugar content is low. Avocado is a "complete food" in terms of protein, containing 9 essential amino acids although not in proportions. Hass contain about 2.4 % 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. Avocado is also the main component in Guacamole a major commercial product used as a favourite dip with potato chips and tortilla chips and similar products. 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 are sporadically grown near house in garden as shades, shelter, intercrop, and beautification etc with little or no manage mental inputs.

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. Avocado oil has become very popular in Western Countries as cooking with avocado oil can reduce blood cholesterol thereby assisting in the prevention of heart disease. It is also the highest protein providing fruit whose protein levels are even higher than those found in banana.

3. 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, to maroon and light to dark purple. 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. It exhibits a unique mechanism for alternation of sexes that enhances the opportunity for out crossing. Hence, unlike some plants, the avocado cannot possibly produce a fruit from each flower. 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. Protogynous, 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
- During the first open period, the nine stamens reflex outward against the perianth, and the pistil stands erect with the stigmatic surface receptive to pollen
- There is no dehiscence of anthers at any time during the first opening. 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, as the stamen valves open and pollen is released (Fig.1).
- The stigma is commonly discolored or withered and is no longer receptive, so that the flower can no longer function as female.
- The flower remains open in this male stage for several hours, and then closes again, permanently.

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, with perhaps a million flowers opening (first, female stage) each morning in the blooming season in a given climatic area.
- 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.

Time of flowering	A type	B Type
	F-morning, M- afternoon	M-morning, F- afternoon
Morning	Stigma- receptive	Withers
	Pollen- does not shade	Shade their pollen
Afternoon	Stigma- withers	Receptive
	Pollen- shade their pollen	Does not shade

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.
  - This means that in avocado breeding, we do not have to hybridize cultivars in order to obtain segregating variability from which to select—each cultivar has immense genetic variability.

Self-pollination

- Our analysis of flower functioning showed self-pollination to be difficult, but it is by no means impossible.
- Although self-pollination within a flower practically never occurs, pollination among flowers of a single cultivar occurs more readily.
- 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.),* or other causes of differences in internal physiology.
- Adjoining trees of the same cultivar would be expected to have this variability accentuated, plus possible effects from rootstock differences.

- Finally, weather change
- s 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.
- Nirody (1922) noted in his original report on avocado flowering that cool weather or overcast days typically delayed flower opening from several minutes to about an hour.
- Stout (1923) commented: "Cool, cloudy days makes opening of flowers irregular and retarded.
- 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., morning flowers are male and afternoon flowers are female, a behavior that is typical of type B cultivars under more favorable weather conditions.
- Type B cultivars are apparently even more sensitive to lowered temperatures than A types
- The avocado fruit is a large berry, with one seed consisting of a double seed coat, two fleshy cotyledons and a small embryo.

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.
- The races hybridize freely and hybrid cultivars have become very important in commercial plantings.
- 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
- Although small fruit sized trees are Mexican race that adapt to medium to high land areas other large fruit size trees are difficult to trace to either Guatemalan or West Indian or to their hybrids that either Guatemalan cultivar domain or not
- However due to long periods of continues segregation & crossing among the seedlings trees, currently diversity of avocado types & hybrids exist in Ethiopia (Edossa 1993).
- Great effort is under way to select local superior avocado lines, with higher yield.
- Some commercial avocado cultivars Furete, Hass, Nabal, Bacon, Pinkerton, Ettinger are popular known cultivars available at Jimma. Their properties are shown in

Table 1: General properties of avocado races

Race	Fruit				Seed		Tolerance	
	Size	skin	oil%	months to ripen	size	cavity	cold	salt
Mexican	Small	thin	high	6	big	loose	Yes	no
Guatemalan	Var.	warty	med.	9	small	tight	Med.	no
West Indian	Var.	leathery	low	6	big	loose	No	yes

Cultivar	Flower type	Races	Oil content (%)	Cold resistance	Maturity season
Furete	B	Mex. x Guat.	18	-2 to -3^{0}c	Mar-May
Hass	A	Guat.	25	-2 to -3^{0}c	Oct.-April
Bacon	B	Mex. x Guat.	18	very sensitive	May-Oct.
Nabal	A	Guat.	16	-1 to -2^{0}c	Dec.-May
Pinkerton			24	-1 to -2^{0}c	-
Ettinger					April-May

Table 2: Avocado cultivars and their properties

4.**Ecological requirements: avocado**

- Produced practically in tropical and subtropical with latitude of 40 ^{o} N and S

- Avocados have wide adaptability that can grow from sea level up to more than 3000 masl and could grow with rain fed where rainfall of more than 1000mm/annuum with uniformly distributed (Durand1990and Samson 1987).
- 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**

Avocados can be grown in Bhutan at altitude 300masl to 1300masl. Avocados are normally subtropical except for the West Indian varieties which can be grown in tropical areas. West Indian varieties grow will in warm humid climates with monsoon rains and optimum temperature of 25-28^{o}C. This race is susceptible to frost however, and temperatures below 1.5^{o}C damage the plant. The Mexican races possess greater winter cooling tolerance and are able to be grown at a minimum of minus 4^{o}C to $^{-}$5^{o}C without suffering any damage to the plants wood and leaves, although flowers are damaged. The Guatemalan is adaptable to a cool tropical climate but is less tolerant of low temperatures. Guatemalan races have been shown to tolerate a light frost of $^{-}$2^{o}C however flowers are damaged by even lighter frosts. For both the Guatemalan and Mexican race (types A & B), temperatures of 15-20^{o}C 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. The Mexican type is good for colder regions because of this very factor. Avocados are also easily damaged by wind due to the plant having brittle branches. Moderately high winds can cause severe damage. 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. Generally, a moderate rainfall range between 1250mm to 1750mm

per annum with good distribution is desirable. 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, consequently the tree needs well aerated soils, ideally more than 1 m deep. Avocadoes can however, tolerate both alkaline and acidic soils. Sandy loam is best

5. 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 ^{0}C decrease yield
- Large fruits with a dark green and sometimes rough skin.

The Mexican race

- Originated in highland areas and is well adapted to cool conditions (highlands) in the tropics and to subtropical areas 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 and to the fungus diseases which accompany such a climate.
- These require lower temperature than other races
- Mature trees can with stand temperature of 5 to -4 ^{0}C without damage to foliage or wood flowers, however, are damaged by frost in areas prone to frost.
- These races require a lower humidity than West Indian race but better fruit set is required with higher humidity at flowering time (example Bacon).
- This race can occur at an altitude of between 1550-3000 m.a.s.l
- It is intolerant of calcareous soils and high soil salinity.
- Slender, pear-shaped fruits with a light green color and almost smooth skin

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 -2^{0}C, but the flowers are sensitive to frost (example Hass)
- Compact, spherical fruits with a smooth, green skin or with purple or black, leathery and warty skin, the so-called alligator type

6. 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 because bees much prefer citrus blooms and will travel much distance to find them although they are the principal pollinator in Avocado

7. 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; seedlings vary according to production and quality of fruits, even when they originate from the same mother tree. Since seedlings grow vigorously, vegetative growths dominate and most of the fruit lets are aborted.
- They also start bearing after 8-10 years of planting, while grafted trees produce yield after 3 to 4 years of planting.
- Propagation by seed used to establish small family orchards, for disseminating rootstocks and in research institution for selecting and breeding new cultivars
- Seeds must be collected from only healthy root stock cultivars and vigorous mother trees & fruits which are mature & sound.
- Seeds loose viability within 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 (49-52^{0}C) for 30 minutes to prevent infection with *P. cinnamomi*.
- After about four to five months seedlings reach grafting at Jimma and wedge/cleft graft is an easy way to join avocado scion with rootstock.

- Grafted avocado seedlings reach field transplant after 9-10 months (sowing in Sept.-Oct., grafting in Jan.-Feb., Field planting in June).
- Commercially avocado can be grafted on rootstock tolerant to avocado root rot (P*hytophthora cinamoni*)

Planting

- Avocado trees brought from a nursery should already have been hardened.
- Plant the trees as soon as best after receiving them. Do not place the trees in the sun since the sun contains become hot and could burn the roots before planting.
- Plant only known variety of grafted seedlings from known sources
- Plant A and B type that produce flower at a time
- Neither tree spacing on its own, nor tree thinning alone can be regarded as the best orchard practice to maximize initial fruit yield of a given avocado orchard.
- The avocado spacing depends on the expected size of mature tree which depends several factors
    - Vigor of the rootstock
    - Cultivars natural growth habit (spreading and erect etc.)
    - Soil conditions (type and depth)
    - climates and others
- This should be made for each growing area, initially plant at spacing to accommodate the mature tree size, plant as many trees as economically feasible, using precocious cultivars and then thin with courage.
- The closest initial tree spacing 4-6 m x 4-6 m that is economically feasible is the spacing that attains high enough yield to make some profit before the first thinning.
- In many countries 400-800 trees/ha of grafted avocados are planted. However, seedling trees require more spacing from 8-12 m x 8-12 m area is required for each plant depending on the soil fertility & management.
- During the early years of an orchard it is desirable to plant a cover crop or others (pine apple) to protect & maintain the soil until the trees can cover it with shade.
- Such corps must not, however, compete with the trees & must be restricted to the strip between the tree rows.

Irrigation

- Irrigation of young trees is important to ensure a uniform stand. Although over irrigation is harmful, too little water can also cause damage.
- Avocados are sensitive to moisture stress. In addition, in nursery the trees should have been accustomed to regular water application and they also still have a limited root system as a result of the limited soil volume in the nursery bag.
- It is there for essential to ensure that water reaches the limited and shallow root system during early years. Small basin around the tree will help to ensure that root system gets enough water. Apply frequently light irrigation.

- Avocado can grow on different types of soil, but well drained soil with a minimum depth of about 1m. is required.
- Good drainage is very important because the avocado is very sensitive to "wet feet".
- Poorly drained soils also predispose the avocado tree to water borne fungal disease such as P*hytophthora ciinnamomi* which causes root rot and serious avocado diseases.
- The amount of water required depends on the soil types, weather conditions and the size of the tree.

Fertilization

- It is important not to fertilize young, transplanted avocado trees soon. They must first become well established and start growing vigorously before any applications are made, preferably after one year.
- Under no circumstances must fertilizers be applied against the stems of young trees. Fertilizers must be spread evenly about 0.2m from the stem to about 0.5m outside the drip area of the tree.
- Since the avocado tree is very sensitive to root damage, each fertilizer application must followed by a light, followed by a light, controlled irrigation.
- Fertilizers must be worked in. The rate varies according to ages, bearing capacity of the trees etc.

8. 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 colure. With dark colored cultivar, this is somewhat easier since these are ripe when one half to three quarters of the final colour has developed.

- The yield of seedling trees varies from non-bearing to exceptionally high yielding. When the yield is small the tree tends to give uniformly year after year.
- However, as the yield increase the tree tends to bear biennial further in extreme cases as the yield increases, the tree gives irregularly. There an indication that some trees gave up to more than 9 quintals at a time irregularly.
- Although avocado fruit can be left (storage) on the tree ``hanging on" for more than 3 months without any quality loss, `hanging on' prevent the tree from flowering. These could reduce the next yield.
- Immature fruit don't become soft of the skin creases after 7 to 10 days. Avocado ripen according to climatic conditions and cv.
- Maturity in the green types is indicated when there is a yellowish tint to the skin and stem. The fruit becomes smoother, especially at the end opposite the stem, and on, any cultivars, all, corky areas appear on the skin.
- 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.
- If these soften without shriveling within week at about 27^0C, then the crop is ready for picking.
- Other method of maturity is a laboratory test which determines the oil content of the fruit.

Pests

- Avocados are highly susceptible to root rot caused by *Phytophthora cinnamomi* in the soil.
- This fungus disease develops when soils are temporarily waterlogged or even kept moist for long periods by excessive rainfall or irrigation.
- Once infected, the trees either die or their growth is inhibited. Avocado should not be planted on soils that are subject to flooding or have poor drainage.
- Presence of avocado trees in high-rainfall areas may not mean that they have resistance to phytophthora root rot; there may be low levels of the bacteria in the particular location, or the tree may have avoided a lethal infection by somehow maintaining a partially health root system.

CHAPTER 4. Apple production and management

At the end of this section students will be able to:

- Explain origin and distribution of Apple
- Analyse nutritional use and composition of Apple
- Describe botany and morphology of Apple
- Discuss Apple cultivars
- Select and identify ecological requirements of Apple
- Recognize pollination of Apple
- Demonstrate cultural practice of Apple
- Discuss harvesting and post-harvest handling of Apple
- Identify pests and diseases of Apple

Apple (*Malus domestica*)

1. Origin and distribution

Apples are fruits that are native to temperate regions. Apples are among "top deciduous fruits". It is the top deciduous fruits are divided in to "pome fruits" (apples, pears, and quince) and "stone fruits" (plums, peaches, etc.) depending on the nature of seed and its formation

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. Lack of cold is likely the limiting factor in tropics. Apples can be adapted to the cool highlands of the tropics ranging 2000-3000 m.a.s.l. 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. The trees were also introduced in to Chencha area in the early 1970th by missionaries. Tseday horticultural farm was engaged in producing apple fruits for more than ten years on small scale basis. Ethiopian, highlands have the potential for growing apple fruits. Production under smallholder holding has been almost negligible. Certain efforts are currently undergoing to promote apple fruits in the highlands of Ethiopia. Chencha Kalehiwot Development Project, GTZ-SUN Oromia, Ethiopian Orthodox Church, SIM project etc.

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, KNO_3, thiourea, cyanamides, and mixtures of cytokinin and gibberellins.
- Rest avoidance (training of branches nearly horizontally => facilitates axillary buds growth)

Composition and use – Reading Assignment

2. Botany and Morphology

Apples are among temperate fruits. It is one of the most widely cultivated tree fruits and belongs to the family of Rosaceae 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. Fruits have rounded shape with a depression at the top where the stem is attached. Fruits are firm and the skin is shiny and smooth with red, green, yellow or combination of those colors. 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

3. 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 are becoming known for growing in the central highlands of Ethiopia. Gran-smith and apple type “BR” are known at Chencha.

4. Environmental factors

Latitudes

- Mostly confined to the middle temperate latitudes ranging 30^0 to 50^0 in both hemisphere

- Apple zones of lower than about 35^0 latitudes must be of low chilling species or else sited at high elevation
- Apple zones are also extended in to higher latitudes ($> 50^0$) by the warming influence

Elevation

- Higher elevation is colder than low once

5. Dormance

- Denote the visibly inactive state
- Condition of a bud charaterized by lack of visible growth and plants are not in leaf
- Temerate zone fruits stop growing in late summer or fall, drop their leaves in fall, are dormant during winter, and resume growth in spring

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 when made continously avaliable for the required length of time
- Effective chilling temperature to terminate endodormance are between 0 to 7^0c
- The chilling required to break dormance varies among plant species
- Most varities requires winter chilling for about 1000 to 1600 hours

Propagation

There are two basic methods of producing a fruit tree: by **using seed (sexual)** or **vegetatively (asexual)**, using, for example, cuttings, grafts and layers. Budding and grafting are commonly used. Selection of rootstock should be made based on the objectives

- Tolerant to soil and climatic condtion
- Stability
- Yield efficency
- Fruit quality
- Size control

The most commonly used rootstcks are

- Malling 27(M27)-exterimely dwarfing type
- Malling 9(M9) –Dwarf type
- Poland2(p2)-25% smaller than m9
- Malling 26(M26)-more vegiourse than M9
- Malling-merton111(m111)-standard
- Malling 7(M7)-semi dwarf
- Poland 22(P22)-semidwarf
- Poland 1(P1)-similar to M7
- Malling merton106(M106)-semi vigourse

Planting

A year old trees with lateral branches are prefered to trees with out laterals. Grower can recives trees that have scaffold branches with wide crotch angles. Branched trees become productive sooner than unbranched ones. >4 years old seedlings are too old for planting. Prunning is needed for about three years to produce good framework.

Correct training & pruning are essential for:

- Early production
- Sustained high yields
- Optimum fruit quality, and
- Efficient management (reduce the work of maintenance pruning)

Objectives of Training

- To develop a strong structural framework capable of heavy crops in future years
- To produce trees that would be easy to manage in later years
- Training young tree should start at planting time
- The approch to training young trees varies depending on the growth habit of the cultivar
- Spreading habit can be trined to conic shape with little effort
- With vigorous, upright-growing cultivars, careful attention must be paid to scaffold selection and limb spreading to obtain the desired tree structure
- For maximum strengeth and fruit-carrying capacity, a scaffold limb should develop with a wide crotch angle at trunk (60^0)
    - If it become vertical

  it dominate leader shoot,
    - Create bark inculsion which make the crotch much weaker and
    - Act as a potential site of decay and entry of pathogens
- Horzontal water shoot sprout over it

Improper pruning and training resulted in to open-center trees

- unproductive structural elements (even though extremities are fruitful units)
- tend to be globular in shape with a dense canopy at the top which heavily shades the lower half of the tree
- **Proper** pruning and training resulted in cone/conical or pyramid shape trees
    - Fewer and well-spaced scaffold branches
    - Shorter branch in the top, and the branches are productive all the way in to the trunk
    - Significantly less structural wood per unit of bearing surface than open-center trees

- Consequently, a greater proportion of the products of the leaves is available for fruiting

Pollination

- **Self-fruitful- self pollinated**
- **Partially self-fruitful** - require cross pollination (or benefited significantly by cross pollination)
- **Self-unfruitful** (sterile) -require cross pollination

- Pollinizer 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 pollinizer into orchards**
  - ✓ Inter-planting along with choice variety
- **Determination of proportion…?**
- **Planting plans, spacing, and management of pollinizers**
  - ✓ Top working (in established orchard)
- **Grafting**
- **Budding**
- Better pollinated fruits contain more seeds, and are larger in size
- The **number** of seeds per **fruit** is a measure of successful pollination and fertilization.
- An apple that contains only a few seeds is more likely to drop before reaching maturity, especially if water, nutrients or carbohydrates are in short supply **l**
- Besides affecting fruit set, seed count affects several fruit quality parameters, especially fruit size and weight
- A low seed count has often been found to correlate with ribbed or malformed fruits

- A high seed count has also been associated with reduced fruit length-to-width ratio, increased firmness, and increased acidity
- Fruits with a higher seed count had a bigger diameter in relation to length

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.
- Most of the flower buds for next year are initiated during a 4-to 6-week period following full bloom (should be done before this time)
- Remove fruit by hand. Leave one apple per cluster, and space the clusters about every 6 inches.

Diseases and insects

- Powdery mildew (shoot, Leaf, Flowers)
- Scab lesion (leaf, fruit)

CHAPTER 5. Grape production and management

- Explain origin and distribution of Grape
- Analyse nutritional use and composition of Grape
- Describe botany and morphology of Grape
- Discuss Grape cultivars
- Select and identify ecological requirements of Grape
- Recognize pollination of Grape
- Demonstrate cultural practice of Grape
- Discuss harvesting and post-harvest handling of Grape
- Identify pests and diseases of Grape

Grape (*Vitis* spp.)

Grapes, which belong to the Vitaceae family, are one of the world's major fruit crops. The European grape *(Vitis vinifera* L.**)** is believed to have originated in the area between the Black and Caspian Seas, where it still grows wild. About 18 species of grapes that are important to

viticulture (either as fruiting or rootstock) are native to North America. Although grapes are used mostly for wines and juices, considerable amounts are consumed as fresh (table) grapes, jams, and jellies and dried into raisins. Over 90% of the world's grape production comes from *V. vinifera* cultivars.

Grapes are known to have been an early introduction to Ethiopia, probably from the Mediterranean area, though reliable records are not available.

Commercial grape growing, largely for the manufacture of wine, was started during the first half of the 20th Century by various enterpreneurs who established vineyards in "Shea", central part of Ethiopia-Gackson et al., 1985). Currently, some 130 accessions of local and introduced cultivars are established at Melkassa and Debre Zeit Agricultural Research Centres, and Merti State Farm.

It is believed that Ethiopia has enormous potential for the successful production of grapes. Unlike in temperate countries, where the crop is widely grown, it yields twice a year in many parts of Ethiopia: if proper pruning procedure and irrigation schemes are followed. The tradition of wine making has been started a long time ago.

Currently, different types of red and white wines are produced in the country for local and export markets. However, the overall annual production has not yet satisfied the present local demand for grape (i.e., home and industrial consumption).

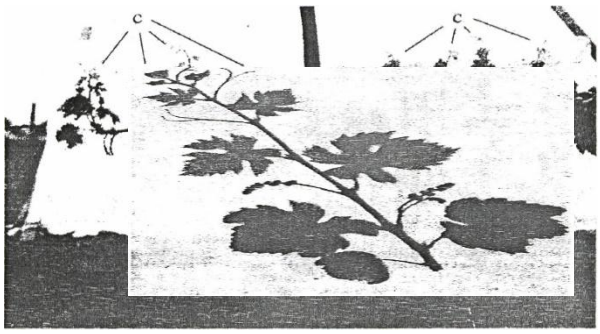
1. Botany

The root system of the cultivated vine is spreading. Under conditions that favor growth, the roots spread over a wide area, permeating the soil mass to a considerable depth.

The shoot system consists of the above-ground parts of the vine. These parts are the trunk, the anus, the shoots (canes, when mature), and the leaves. The succulent growth arising from a bud is called a *shoot.* When the shoot becomes woody, matures, and drops its leaves, it is called a *cane*. The shoot of a vine is divided into several distinct parts: the growing tip, the nodes, the inter-nodes, the buds, the tendrils and the laterals. A bud of the vine usually consists of three partially developed shoots, with rudimentary leaves or with both rudimentary leaves and flower clusters. These are compound buds, often called "eyes"

Under normal conditions only the middle one of the three partially developed shoots (the primary growing point) of the bud grows when the vine leafs out (flushs) in the following spring. If it is destroyed, the more advanced of the lateral growing points will grow. Under abnormal conditions (such as over-severe pruning, destruction of part of a vine, or a boron deficiency) two or even all three of the growing points may burst into growth. The buds of the vine may be classified according to (a) the nature of the structures they contain, or (b) their position on the shoot or arm.

A horizontal bilateral cordon: (a) trunk (b) arm (c) bearing unit/shoot (cane when mature)



Adapted from: Winkler et al. (1974)

Figure - A shoot showing the relative position of the leaves, flower clusters and tendrils.

Source: Winkler et al. (1974).

As to the nature of the structures they contain, buds may be leaf buds or fruit buds. The *leaf bud* in the grape is a rudimentary sterile shoot; that is, it elongates into a shoot that bears only leaves and tendrils. Thus, a shoot arising from a leaf bud cannot bear fruit. A *fruit bud* contains a shoot having both rudimentary leaves and flower clusters (Fig.8-4).

When a bud of this type unfolds (grows), it produces a leafy shoot that bears one to four (usually two) flower clusters opposite the leaves at the third and fourth, fourth and fifth, or fifth and sixth nodes from the base, depending on the cultivar. In the vine, the flowers are borne in a cluster (or bunch). In position and origin, the cluster very closely resembles' the tendril. The fruit of the grape is a cluster consisting of stems (rachis, branches, and pedicels) and berries. The seeds constitute up to 10% of the weight of the fruit. They are rich in tannin.

Types of grape: Based on their origin

1. **European type (*Vitis vinifera*)** – over 90% world production and grown for wine production.
2. ***Vitis labrusa* (America grape) -** Grown mainly where there is frost problem and for juice, wine, table grape but wine made is inferor to the first one
3. ***Vitis rotundifolia*-** Tolerant to hot condition and Used for fresh consumption and canning

Commercial class of grape (depending upon their purpose)

1. Table grapes (for fresh consumption)
    - Used for fresh market (food or decoration)
    - Attractive in appearance (shape, size, color)
    - Good eating quality
    - Good shipping quality
2. **Raisin grapes**
    - Produce acceptable dry product
    - Should be seedless
    - Have good flavor
    - Soft texture
3. Wine grapes-used for wine making

- **Table wine** (dry or dinner wine)
  - Contain <14% alcohol
  - Produced from grape moderately high sugar content and relatively high acidity
- Dessert wine (Appetizer or sweet)
  - Contain > 14 % alcohol (17-20%)
  - Produce from grape of high sugar content and low acidity

4. Juice grapes
5. Canning grapes
   - Grape canned in combination with other fruits
   - Seedless

2. Ecological requirements

Grape requires a deep, loamy soil with good structure. It must contain organic matter and should be very well drained and aerated. The ideal pH range is between 6.5 and 7.5.

In Ethiopia, the highest altitude limit for commercial production is reported to be 2000m. The lower limit has not been defined, but at localities like Abadir, which is 1000m m.a.s.l., grapes have been grown successfully for a number of years.

From about 1,800m to 2,000m only one crop (harvest) a year can be produced but rain-fed production is possible provided precipitation is not less than about 800mm/year. Supplementary irrigation is necessary to obtain higher yields.

Below about 1700m, the temperature is high enough to produce two crops in a year, because the growing period is shorter. However, supplementary irrigation is essential in order to produce two crops.

Grapes grown in the cooler climates are reported to be of better quality for wine making as they develop more color and have a higher tannin content, on the other hand, grapes grown in warmer areas have higher total soluble solids.

Optimum temperature conditions for growing grapes are where mean temperature fall within the range of 20-25^{o}C with low to medium atmospheric humidity. Humid climates favor the development of diseases such as downy mildew.

3. Varieties and Crop husbandry

Local cultivars, *"Tikur"*, *"Nech Debulbul"*, *"Kai Dubei"* and *"Nech shul"*, and a number of introduced grape cultivars are known to be grown in Ethiopia. Grapevines may be propagated from seeds, cuttings, layers, or grafts. Since most seedlings are inferior to the parent vines in vigor, productivity, and quality of fruit, propagation of vines by means of seed is uncommon. The seeds are useful, however, in producing new varieties (i.e., for breeding purpose). Propagation by cuttings, layers, buds, or grafts, in contrast, produces vines identical with the parents in all varietal characteristics. Nearly all grape cultivars, whether for fruiting or rootstocks, are multiplied by cuttings.

Layering as a means of propagating vines is recommended under two conditions: (a) to multiply cultivars whose cuttings can be rooted only with great difficulty, or (b) to replace occasional missing vines in an established vineyard.

It has also been reported that grapevines are grafted for any of the following purposes:

1. to obtain vines of the desired fruiting cultivar resistant to nematode or phylloxera (it is not yet reported in Ethiopia);
2. to correct mixed cultivars in an established vineyard;
3. to change the cultivar of an established vineyard;
4. to increase a supply of new or rare cultivars rapidly; or
5. to obtain vines on roots tolerant to certain adverse soil conditions such as high lime.

In Ethiopia grapes are propagated from stem cuttings of mature brown wood which are usually made from the pruning bearing vines. Cuttings should be taken only from healthy, vigorous and high-yielding mother plants which should be selected and marked before harvest, so that they can be recognized at pruning time. Cuttings should be of medium diameter and about 30cm long. Recommended spacing in Ethiopia is 2.5 x 1.5m which allows planting of 2,700 plants/ha.

Grapevines cannot be grown satisfactorily without some kind of support. The supports needed are of two kinds, temporary and permanent. Both kinds help to obtain, a well- formed; vine with a strong, straight trunk, a vine that does not interfere with cultivation and other vineyard operations, and that is free of the defects and large wounds which otherwise diminishes vigor and longevity.

A great variety of support and training systems are in use in different grape producing parts of the world. The system which has been commonly used in Ethiopia is the 3 or 4 wire trellis for supporting the bilateral cordon.

Pruning comprises the removal of living canes, shoots, leaves, and other vegetative parts of the vine. Grapes generally are pruned more heavily than other fruit trees. The objectives of pruning of grapes are to:

1. help establish and maintain the vine in a form that will save labour and facilitate vineyard operations, such as cultivation, control of diseases and insects, thinning and harvesting;
2. Distribute the bearing wood over the vine, among vines, and over the years in accordance with the capacity of the spurs (or canes) and vines, so as to equalize production and get large average crops of high-quality fruit; and
3. lessen or eliminate thinning in the control of crop. Pruning is the cheapest way of reducing the flower clusters.

The number of buds (or length of bearing units) to remain after pruning depends on the vegetative growth of the plant and the sprouting rate. The number of buds, the number of shoots (bearing units) and the number of fruit clusters (grapes) per vine are positively correlated with each other.

It is therefore very important to find the right balance between vegetative growth and yield.

The appropriate number of shoots is 8-10 per m^2, but because of the poor sprouting rate (bud-break) under tropical conditions, one has to prune to 10-15 shoots per m^2 (Jackson et al.,1985).

The buds of the vine may be classified according to:

1) The nature of the structures they contain
   a) Leaf bud – elongates into a sterile shoot
   b) Fruit bud- elongates into fruitful shoot

2) Their position on the shoot or arm
a) Basal buds
b) Middle buds
c) Apical buds

Depending on positions of fertile buds on the canes, three pruning methods are recommended in Ethiopia (Fig.):

Spur pruning*:* This pruning method is recommended for cultivars which have their most fertile buds at the basal part of the cones. It is a very successful method for tropical viticulture; since apical dominance is not very pronounced. In this type of pruning, fully matured canes are pruned to two bud spurs which should be distributed regularly all over the plant. Single bud spurs should be selected close to the trunk for renewal purposes.

Short cane pruning*:* This pruning method is recommended for cultivars which have their most fertile buds at the middle part of the canes. The bearing units are pruned to 4-8 buds. In addition 1-2 bud spurs are necessary for renewal purpose.

Long cane pruning: It is recommended for cultivars which have their most fertile buds at the apical part of the canes. This method is very difficult to manage due to apical dominance. Generally, fully matured canes are pruned to 8-12 buds. In addition to these, long canes 1-2 bud spurs are needed for renewal purposes.

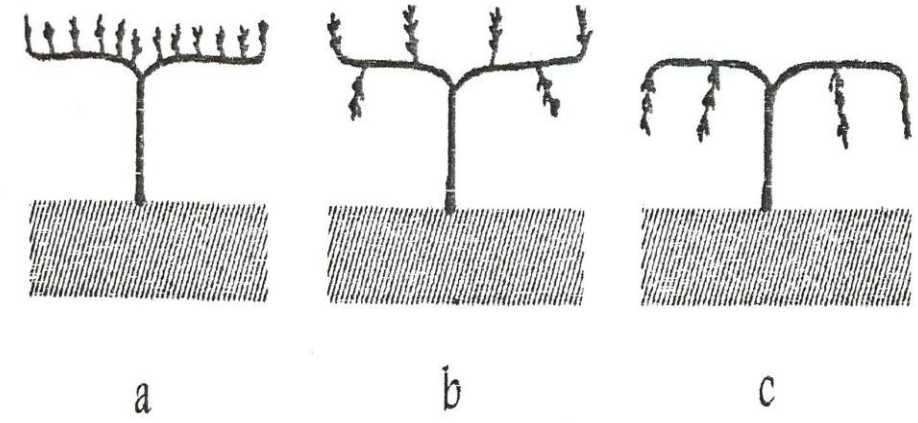


Fig. Types of grape pruning: (a) spur pruning (b) short cane pruning (c) long cane pruning.

Source: J ackson et al. (1985)

Under tropical and subtropical conditions, the time of pruning and consequently the time of the vegetation season should be chosen according to climatic and economic aspects. The rainy season should not coincide with the development of young shoots, flowering' and the harvesting period.

In addition to pruning and training, flower-cluster and berry thinning, girdling, topping and pinching, and the use of plant growth regulators are practiced to improve grape quality.

The major diseases of vineyards in Ethiopia are *downy mildew, powdery mildew* and *cluster botrytis rot.*

Downy mildew is a very serious disease which attacks leaves, shoots and clusters. On the lower of leaves a white downy mass will be visible. As the disease progresses, the spots will turn brown and the leaves may drop. Downy mildew is a problem during moist weather, Prevention is by sprays of fungicides (Copper fungicides, based on copper oxychloride), Elsewhere other chemicals such as antracol, benomyl, mancozeb, and pomuran are used.

Powdery mildew is another serious disease on grapes. The presence of white, powdery mycelia on the surface of the leaves or any green part of the vine signals the disease, which is spread by wind-borne spores that germinate when leaves are dry. During warm, dry weather, leaves should be dusted with Sulphur to prevent germination of the spores. Once the disease has begun, benomyl or wettable Sulphur sprays are used for control.

Cluster botrytis (grey-mold) rot is another serious damage causing disease on clusters of grapes. It causes the grape skins to crack and the berries to turn brown and dry into a sort a moist raisin. The disease may occur on ripe grapes in the vineyard (before harvest), in transit, or in cold storage. The best way to control the disease is the use of chemicals controlling downy mildew (captan, folpet, and others).

4. Harvest and post-harvest handling

The stage of maturity at which grapes are harvested depends on their end use. A reliable method of determining harvest maturity is by taking samples of the berries, expressing the juice and measuring the total soluble solids content (TSS) by means of a hand refractometer. The TSS in degrees Brix of grapes at harvest maturity for different end uses is shown below:

Table grapes (grapes for fresh consumption) .... ^{0}Brix

Raisins 18-20

Light white wine 17-18

Heavy red wine 22-23

Fruits for fresh consumption (table grapes) should be handled carefully so that the bloom on the skin of the berries is not damaged. Cool storage temperature (0^{o}C) and 95% relative humidity for periods of up to six months with periodic fumigation to control disease are recommended.

Grapes for wine making do not require so much care in harvesting. They should be harvested into bulk containers which are moisture proof and transported to the winery as fast as possible and under cool conditions to avoid fermentation.

Types of flower

1) Hermaphrodite –Self-fruitful
2) Female (Pistillate) – Self unfruitful
3) Male (Staminate) – Self unfruitful

Ecological Requirements

Soil;

- Can be grown on most soil types provided there is good drainage
- No impermeable layer within a minimum depth of 1.3m below the surface
- Deep loamy with good structure
- pH – The ideal pH is between 6.5 & 7.5

Altitude

- The top altitude limit for commercial production is 2000masl,above these there is frost damage
- From 1800 to 2000 m only one crop/year can produced
- Below about 1,700 m temperature is high enough to enable two crops/year because the growing period is shorter but supplementary irrigation is essential
  - Two crops around Ziway and Merti

Temperature

- The optimum temperature condition for grapes are where mean temperature fall between $20 – 25^0$C
- Grapes grown in cooler climates are reported to be better quality for wine making because they develop good color and higher tannin content
- At warmer area they produce more TSS

Heat summation (Degree days / Heat index)

Base temperature = 10^0C

$\frac{\text{Max + Min}}{2}$ - $10\ ^0$C

- Maximum total heat summation => High mean temperature => short crop duration
- Minimum total heat summation => low mean temperature => long crop duration

Crop husbandry

- ✓ propagation
  - Seed – for breeding purpose
  - Stem cutting (Hardwood)
  - Layering (simple layering)
  - Budding (Chip budding)
  - Grafting (wedge, splice, cleft)
- ✓ Why grafting?
  - To improve yield (productivity)
  - To improve tolerance/resistance to diseases/pests
  - To change mixed or inferior varieties
  - To improve adaptation to problematic soils (saline, acidic, waterlogged etc.)
- ✓ Most American type grapes are used as rootstocks because they are:

- Tolerant of nematodes
- Tolerant of salinity
- Water-use efficient

WHY ROOTSTOCKS?

- Rootstocks offer grape producers a risk avoidance strategy
- While own-rooted vines will produce appropriate yields of high quality fruit, root systems of *Vitis vinifera* vines run risks associated with rootzone pests, diseases and adverse conditions such as poor nutrient status or salinity
- Rootstocks provide solutions to many of the risks present in the root zone

Propagation by stem cutting (hardwood)

- Common method in Ethiopia
- Simple & cheap

Spacing (depends mainly on)

- Vine vigour
- Training system
- Pruning method to be followed
- Fertility level of the soil & climatic factor

2 x 2 m
2 x 1.5 m
1.5 x 1.5 m

- **Training –** aims at giving proper shape
  - Maximize production, facilitate cultural operations

➢ **Why training?** The growth of grape is influenced by apical dominance

- **Trellise** (support provision)

. Temporary or permanent and 3 - 4 wire trellise system

- **Pruning –** removal of vine part

Pruning procedures:

- Thinning out
- Heading back

Pruning – objectives

To help establish & maintain the vine in a form that will save labour & facilitate vineyard operations. To distribute the bearing wood over the vine, among vines, and over the years in accordance with the capacity of the spurs (or canes) & vines, so as to equalize production & get large average crops of high-quality fruit. To lessen or eliminate thinning in the control of crop. The number of buds, the number of shoots (bearing units) & the number of fruit clusters per vine are positively correlated with each other. Appropriate number of shoots is 8-10/m^2
(10- 15/ m^2 because of poor bud sprouting

Pruning methods; (Depending on position of fertile buds**)**

- **Spur pruning –** Recommended for varieties which have their most fertile buds at the *basal part* of the canes
- **Short cane pruning -** Recommended for varieties which have their most fertile buds at the *middle part* of the canes
- **Long cane pruning -** Recommended for varieties which have their most fertile buds at the apical part of the canes

Improving fruit quality

How?

- Training & pruning
- Flower & berry thinning
- Girdling
- Topping/pinching
- Use of plant growth regulators

Harvest and post-harvest handling

- Determination of stage of maturity
  - Depends (mainly) on their end use
- TSS (Degree Brix)
  - Table grapes ----------16^0Brix
  - Raisins----------18-20
  - Light white wine------ 17-18

CHAPTER 6. Peach and plum production and management

- Explain origin and distribution of Peach
- Analyse nutritional use and composition of Peach
- Describe botany and morphology of Peach
- Discuss peach cultivars
- Select and identify ecological requirements of Peach
- Recognize pollination of Peach
- Demonstrate cultural practice of Peach
- Discuss harvesting and post-harvest handling of Peach

Identify pests and diseases of Peach

Peach (*Prunus persica* L Batsch)

The peach is the members of the Rosacea family. Peach, which is believed to have originated from China, is now one of the most popular commercial and home garden fruits in the world.

There are two types of peaches-clingstone (flesh firmly attached to the pit stone or endocarp) and freestone (flesh separating easily from pit). In both types there are yellow-fleshed and white-fleshed cultivars.

Clingstones generally appear better canned than freestones. This is because clingstones' flesh is firm enough to retain its shape during canning. Freestone peaches are used to some extent for canning, but they are mainly eaten fresh.

Despite lack of sufficient winter chilling temperature, which is necessary for breaking dormancy, peaches have shown a good adaptation in Ethiopia. Upland areas like Holetta are suitable for successful peach production. Cultivar *Ventura* peach is found to be promising as tested at Holetta (National Deciduous Fruits Research centre).

For best tree growth and production of peaches, a deep, reasonably fertile, well-drained sandy loam soil is preferred. Heavy and poorly drained soils should be avoided.

Peach is usually propagated by budding scion (T-budding) onto desirable peach seedling rootstocks. A spacing of 6x5m or 5x4m can be used depending on cultivar, soil type, and management (mainly pruning practice).

Young peach trees are generally pruned to an open-centre or vase-shaped form, keeping the pruning to a minimum to avoid growth retardation and a delay in the onset of bearing. Peaches bear fruits laterally on shoots that have been grown in the previous summer. Thus, relatively heavy pruning of mature trees is necessary to ensure a continuing supply of vigorous shoots. If the trees are not pruned, little shoot growth takes place and fruit production is low.

Diseases and pests of peach and nectarine include:

Leaf curl is perhaps the most widespread peach disease. Young leaves are attacked, causing thickening, curling, and defoliation. Control is by fungicidal spray such as Bordeaux, or copper and oil applied once during the dormant period and again when buds are swelling.

Insect pests of stone fruits include three species of scale: *pernicious scale, red scale,* and *grey scale.* Control is primarily through the use of chemical sprays during the dormant period.

Harvest and post-harvest handling

Peach fruits are mature and ready to pick when the skin background color becomes creamy yellow. They continue to ripen and soften after picking but the highest-quality fruits are those allowed to become fully ripe on the tree. Although the fruits are not adapted to long storage, they can be stored for two to four weeks, depending upon the cultivar and harvest maturity, if stored at about 0^0C and 90% relative humidity.

Plums (Prunus spp.)

There are many species of plums of which three groups are economically important: The North American plum (over 100 species), the European plum *(Prunus domestica),* and the Oriental plum *(Prunus salicina).* Of these, only the oriental plum is likely to succeed in the tropics, but it is essential to choose appropriate cultivars that suit best to a given agro-ecological zone.

In order to maintain true-to-type cultivars, propagation is by budding/grafting or in some cases by hardwood cuttings. In most cases a planting distance of 6x5m is used. A spacing of 5x4m is also known to be sufficient if crop trees are regularly pruned. Pruning is recommended to keep the balance between vegetative growth and fruiting. Most oriental cultivars are self- sterile and require other cultivars for pollination. At present plums are grown in and around Addis Ababa. The potential for further expansion to areas with similar agroecological conditions (probably altitudes ranging from 1,700-2,600m) in the country seems high.

CHAPTER 7.

Strawberry production and management

Strawberry (Fragaria spp.)

The strawberry, a member of the Rosacea family, is a popular fruit wherever it is grown with

proper selection (short- day or day- neutral cultivars). This fruit produces well in the tropics at altitudes above l000m. The plant is a low- growing herb and reproduces naturally by runners or stolons. The production of flowers and stolons is controlled by the length of the day. Flowers are produced in short days and stolons in long days. Since days are uniformly short in the equatorial tropics many cultivars produce fruit over a long period but produce fewer runners than when grown in temperate regions. Storing plants at 0^0C for three weeks prior to planting and exposure to long days through artificial lighting will often increase runner production when it is desirable for propagation purposes (Rice et al., 1994).

In Ethiopia the crop has been grown for many years and has also been the subject of research. Many introduced cultivars were evaluated and the Californian cultivars "Tioga" and "Aliso" have been found to be the most successful.

Light to medium textured and well-drained soils are more suitable than heavy soils. The water holding capacity of the soil should be good. The climatic (temperature) at an altitude of 1,600 to 1,900m are very suitable for strawberry production in Ethiopia. In cooler (above 1,900m) and warmer (below 1,600m) climates, results are less favorable.

Owing to the highly perishable nature of the fruit it is important that production should be located within reasonable transport range of the market outlet.

Strawberries are propagated vegetatively from runners. A single runner may give rise to several plants. About 30 plants can develop from a runner maintained in a nursery (growth medium). Identified and certified plants are recommended for multiplication purposes.

Propagation by splitting up the crowns of old fruiting plants is also possible, but not recommendable as the/ results are generally unsatisfactory. The spacing used for strawberries are: 80x60cm (for multiplication of planting material) and 90x60x30cm (for fruit production in double row planting system). Strawberries must be planted carefully so that the crowns are leveled with the soil surface because deep or shallow planting is harmful to the plants. Roots should be spread out and not bent. Irrigation must be frequent after planting since the root system is adventitious and shallow rooted.

After the plants are established, they can either be grown in the *matted row system* where all runners are allowed to remain and a solid cover of the bed is obtained, or the *hill* or *mother plant system* where runners are removed and large single plants are formed. The *matted row system* has the advantage of smothering weeds but yields may be reduced if the plants become too crowded.

The *mother plant system,* which is generally preferred in warm climates, is high-yielding and allows for better air penetration which in turn reduces the chance of an outbreak of disease. Plants should be mulched with straw or plastic sheeting 'or other materials.

Under local conditions, strawberries are always in the flowering phases and will start to produce flowers a few days after planting. It is necessary to remove all flowers by hand. In the case of plant

multiplication blocks, deflowering is continued so that the assimilates are used for runner production. In the case of fruit production crops, deflowering is continued only until the plants have grown to a full size to adequately support fruit growth. The period of deflowering may last for about four months and deflowering should be carried out once weekly.

The economic life cycle of strawberry will be determined by a drop in yield and decrease in fruit size. Under favorable conditions a cropping period of 10-12 months may be expected, that is, beds should be replanted each year or at the latest every two years since older plants do not yield well.

The strawberry is susceptible to many diseases and nematodes. Nematode problems are prevented either by growing plants in soil which has not previously grown fruits or vegetables that are sensitive to host nematode. Plants used for propagation should also be free from nematodes. Virus diseases can be prevented only by obtaining plants from nurseries producing virus-free plants. In many instances, this is nearl

y impossible. So the best option is to use only those plants which are free of obvious virus symptoms. Thus planting with discoloured, crinkled or misshapen leaves should be avoided.

Leaf spot and *grey mould* are the most serious fungal diseases. Leaf spot forms small black spots on the leaves in the rainy season and can be controlled by spraying fungicides (captan or copper oxychloride). Grey mould is a problem on fruits during wet weather. When fruits are infected by grey-coloured mycelium, they will rapidly soften and spoiled. Control is possible by using disease free mulching material (to keep fruits off the ground), adequate plant spacing to allow air circulation and periodic sprays with captan carbendazim dicloran or vinclozolin.

Once harvesting is started, it is likely to continue for a period of 10-12 months. The fruit must not be in contact with the soil which can be achieved by mulching. The fruit is harvested when it is still firm but almost fully coloured. Fruit is picked from the plant by nipping the stalk between thumb and finger. Strawberry fruit is highly perishable and so should be picked carefully with the stem being attached and then placed directly into the containers in which the fruits will be sold. A storage life of 7 -14 days may be expected if the fruit is stored at 0^0C as quickly as possible at a relative humidity of 95%.