MEKDELA AMBA UNIVERSITY

COLLEGE OF AGRICULTURE AND NATURAL RESOURCE

DEPARTMENT OF PLANT SCIENCE

Fruit Crops Production and Management Handout (For 3^{nd}year Plant Science Students)

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CHAPTER 3: PLANNING AND ESTABLISHING ORCHARDS

3.1. Site Selection

Each species of fruit has specific environmental requirements which must be meet for optimum growth and production. Land survey is a very important prerequisite for the foundation of a new farm or re-organizing an existing farm. Major aspects of land use planning which should be investigated are climate, soil, vegetation nature and previous cropping history, topography, irrigation potential, infrastructure, logistics and communications in relation to markets. It is extremely important to learn as much as possible about the weather of the proposed planting site. Meteorological information can often be obtained from neighbors who have lived in the area for many years, national meteorology (government weather services) or any other sources. Several weather conditions (climatic factors) are particular importance in fruit growing.

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

The optimum temperature range vanes from one fruit crop to another. In general, some crops have high rates of photosynthesis combined with normal rates of respiration with in a relatively low range, and other crops have high rates of photosynthesis combined with normal rates of respiration at a relatively high range. On these bases, Edmond et al. (1983) classified fruit plants as follows:

- Fruit crops which produce their highest yields at a low temperature range (7 – 13 °C),
- Fruit crops which produce their highest yields at a moderately high temperature range (l3 – 18 ^{0}C), and
- Fruit crops which produce their highest yield at a high temperature range (18 – 24 ^{o}C). The optimum temperature range for some fruit crops is shown below.

Table 2. Temperature requirements of some fruit crops

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

Rainfall: fruit plants require adequate soil moisture throughout the growing season. Amount and distribution of the annual rainfall can vary widely from place to place. Some areas receive relatively small quantities each year (arid and semiarid) whereas others receive large supplies (humid). In the arid and semiarid areas (where rainfall is erratic and scanty) the application of irrigation water is required for the production of high yields. Conversely, humid areas receive sufficient amounts of rainfall per annum. Since effectiveness of rainfall is more important than amount, the application of irrigation water may serve as insurance for the production of high yields. A better situation exists where water supplies for irrigation are available during times of drought. A pattern of continual rains during the pollination period could result in poor crops by interfering with bee activity. Continual rains during the fruit harvesting period leads to problems, not only in harvesting operations but also in promoting various fruit disease (fungi, bacteria). The proposed site should not be subjected to periodic flooding (from nearby rivers or streams, faulty irrigation, poor hydraulic conductivity), Most fruit plants will not tolerate water around their roots for any length of time, as the water stops air penetration to the roots.

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

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

Elevation: The elevation of the land refers to the altitude of the surface of the land above or below sea level. Differences in elevation make for marked differences in temperature between the two places. Altitude and temperature are inversely related, that is, the higher the altitude the lower the temperature of the site and vice versa. In the tropics for every increase in elevation of 100m, there will be fall in temperature of 06°C. Tropical fruit crops thrive at the low elevations; subtropical fruit crops thrive at the intermediate elevations; and warm- temperate and even cool-temperate crops thrive at the high elevations.

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

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

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

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

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

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

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

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

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

3.2. Land preparation

The purposes of land preparation are:

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

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

The development of new land should be carried out by a contractor since the necessary machinery is too expensive for a single farm. Where the subsoil is strongly alkaline, grading must be reduced to a minimum. Ploughing can be done by disc ploughs, moldboard ploughs, or rotary cultivators. For ploughing fields for fruit production, the moldboard plough or the rotary cultivator are preferred because of their better working quality compared with the disc plough. A recommended soil preparation for deep-rooted fruit crops are sub-soiling (about 90 cm deep), deep ploughing, levelling and ploughing again.

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

On slopes of 10-15 % (in some cases up to 17 %), well maintained terraces are necessary to prevent soil erosion. Generally, combinations of ridging, terracing, and cover crops are necessary in the tropical orchard if severe erosion is to be prevented. Fencing is an important feature of an orchard since young trees are likely to be eaten by animals if they are not protected. In addition, when trees begin to fruit, theft may become a problem. Fencing will help to alleviate both of these problems. However, in Ethiopia fencing is normally accompanied (supported) by alert day and night guards, and the result is said to be quite satisfactory.

Windbreaks- Wind can have a definite harmful effect on fruit production. Where this is a serious problem, windbreaks must be used to decrease the wind velocity and thereby damage to plants. It is well known that windbreaks can result in a 45-60 percent reduction in wind velocity as well as reducing transpiration by as much as 65 per cent (Rice et at, 1990). Ideally, windbreaks should be planted two to three years before the orchard is established so that they are sufficiently large to provide immediate protection to the newly planted orchard trees. The choice of the windbreak species depends on the location of the orchard. Windbreaks should not serve as an alternate host for pests that can attack fruit plants intended to be grown; it should be a tall and multipurpose tree which is strong enough to resist the impact of wind. It should be densely planted to block the wind.

3.3. Laying out the field and digging holes for planting

An important operation in the preparation of the planting site is the laying out of the field. The laying out operation consists of locating planting sites or positions on the field. Materials required for this purpose are ranging poles, measuring chains or tapes and pegs or stakes to mark the planting site. A baseline is adopted at one side of the block in which the planting sites are to be marked. Along this baseline, the various sites are marked at the appropriate distances required for the crop to be planted. If the planting is to be done on the square, prior to planting right angles should be set out using a rope measuring 3m, 4m and 5m in accordance with Pythagoras' theorem planting holes are staked out and large holes 0.6m and 0.6 m width and depth respectively are dug; topsoil should be placed in one pile and subsoil in another. The hole should then be refilled with a mixture of 50 percent topsoil and 50% well-rotted manure, compost, or other decomposed organic matter. In soils where phosphorous is lacking, super phosphate should also be added as the hole is filled. The hole should be allowed to settle for several weeks and then planting can begin. Bare root plants must be kept cool and the roots must be kept moist and protected from the sun. When the bare-root trees arrive, they will be wrapped in banana leaves (where available), plastic, or some other moisture-conserving material. After they are unwrapped, the roots should be immersed in water for a few hours before being planted.

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

Container-grown plants should be removed from their pots (or polythene tubes) and any circling roots should be cut off. Soil is removed from the prepared holes and the plants are then set and covered to the same depth that they were growing in the container. Planting is carried out at the beginning of the rainy season. The most critical period in the life of the orchard or vineyard is the first year after planting. During this time, it is important that plants are not allowed to dry out and need to be protected and are kept free from insect and disease infestations. Mulching is a beneficial practice both to prevent weed growth and to conserve soil moisture. Mulches can be of any organic material including dried grass, banana leaves, chopped plant refuse, and the like. To be most effective, mulches should be ill least 10 cm thick and should be placed in area 1 – 3 m in diameter around the tree but not touching the trunk itself.

3.5. Planting Fruit Tree Seedlings

Prior to ordering the planting trees, an orchard and/or vineyard plan should be drawn on paper to show the location and cultivar name of each tree, irrigation system (if applicable), tree supports, orchard roads and paths, packing shed and any other permanent features of the plantation site. If the plan is drawn properly, the number of plants, stakes, and so on can be determined and obtained before the start of planting. Different planting systems are used in fruits depending mainly on topography of the land, the growth habit of the tree, method of training/pruning and the type of machine intended to be used for the various farm operations. **Canopy** is the part of the tree composed of leaves and small twigs.

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

Total fruit crops population = $\frac{Area\ of\ the\ land}{Area\ occupied\ by\ a\ single\ tree}$

Example: Area of the land = 1.5 ha as well as spacing between the mango plants and rows =10 m. Then, calculate total number of mango tree.

<u>Solution:</u>

Total mango trees population = $\frac{\boldsymbol{Area\ of\ the\ land}}{\boldsymbol{Area\ occupied\ by\ a\ single\ tree}} = \frac{(\mathbf{1.5 \times 10000})\ \boldsymbol{m}}{(\mathbf{10 \times 10})\boldsymbol{m}}$ **=150 mango trees**

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

Total fruit crops population = $\frac{Area\ of\ the\ land}{Area\ occupied\ by\ a\ single\ tree}$

Example: Area of the land = 1.6 ha as well as spacing between the coffee plants and rows are 2m and 3m respectively. Then, calculate total number of coffee population.

<u>Solution:</u>

Total coffee population = $\frac{\boldsymbol{Area\ of\ the\ land}}{\boldsymbol{Area\ occupied\ by\ a\ single\ tree}} = \frac{(\mathbf{1.6 \times 10000})\ \boldsymbol{m}}{(\mathbf{2 \times 3})\boldsymbol{m}}$ **=2666.67 coffee = 2666 coffee population. 0.67 indicates vacant area of orchard.**

Equilateral triangular- Trees with circular crowns (e.g., date palms), are best planted in an equilateral triangular planting system, this allows cultivation in three directions and accommodates some 16 percent more trees per ha compared to the square system. If the distance between trees is d, then a tree takes up $\frac{1}{2}d^2\sqrt{3m^2}$. Let us put d at 10m. Using square planting, 100 trees/ha can be planted. In an equilateral triangle a tree occupies 1/2 x 100 x 1.73 = 86.5m^2, so the density is 10,000: 86.5= 115.6 =115 trees per ha.

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

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

Hedgerow planting- is known to be best for dwarf deciduous trees and requires special pruning and training techniques. The primary advantages are high yield and low labor requirements per hectare. There is now a growing interest in dwarf trees because this allows for high plant density per unit area and yield. Tile advantages of this are much higher early yields, and less expense in picking the fruit, and spraying and pruning the trees. Plant distance within and between rows depends on several factors. The major ones may be as described as follows:

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

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

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

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

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

Chapter 4: Management of Orchards

4.1. Irrigation and fertilization

4.1.1. Irrigation

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

Methods of application

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

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

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

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

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

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

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

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

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

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

4.1.2. Fertilization

Fertilizer application program in fruit plantations

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

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

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

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

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

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

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

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

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

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

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

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

Determination of method of fertilizer application- Fertilizers may be applied to fruit orchids or vineyards by using anyone more of the following methods: broadcasting, basal dressing, side dressing, top dressing, ring application, and foliar application. Application of organic fertilizers such as, farm-yard manure, compost and other organic household refuses, with irrigation water is also common in some parts of the country.

4.2. Training and pruning of fruit plants

Training and pruning are well known and universal practices.

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

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

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

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

Some specific reasons for pruning fruit plants are to:

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

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

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

- ❖ Improve light penetration to the inner and lower parts of the tree.
- ❖ Remove dead, broken, or interfering branches.

- ❖ Facilitate insect and disease control by opening the tree, thus increasing penetration of spray materials to the interior branches and removing diseased branches.

There are two kinds of top pruning:

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

Thinning out: is the complete removal of a branch to a lateral or main, that is, the entire twig, cane, or shoot is removed. Thinning out corrects an overly dense area or removes interfering or unneeded branches. In general, heading back stimulates the development of more growing points than a corresponding thinning out. When branches are headed back, it should be done with a slanting cut at an angle of approximately 45°, just above a healthy bud, with the bud opposite the slant. The lower part of the slant should be above the base of the bud. The cut should be clean and sharp to encourage rapid healing. No stub should be left above the bud and the cut surface should be as small as possible. When thinning out branches should be cut close to the bulge on the main stem leaving no stub. Any stub left will give rise to fungal infection due to delay in healing and this may eventually affect the main stem.

4.3. Control of weeds, diseases and insect pests

A heavy growth of weeds utilizes soil moisture and mineral elements, particularly nitrogen, which would otherwise be better used by the fruit plants. In addition, weeds interfere with orchard or vineyard operations-pruning, fertilization, thinning, irrigation and harvesting. In dry seasons, as the weeds die, they constitute a serious fire hazard and can harbour rodents that will damage tree trunks when food is scarce. In well- managed fruit plantings, where irrigation water is scarce or expensive, weeds should be meticulously controlled. At the early stages of field establishment weeds often cause greater losses than insects or plant diseases. A very important factor in improving growth and development, and thereby increasing the yield of fruit crops, is therefore efficient weed control. The weed control program should be designed in such a way that a weed population is kept to a level where there is no significant competition with the fruit crop being grown. Principal methods of control include the following:

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

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

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

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

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

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

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

The particular herbicide within each group to be used on a particular crop at a given time depends on the nature of the weed infestation, soil type, rainfall and temperature. The close similarity between the response of the crops and that of the weeds in each group emphasizes the principle that the more closely related the crop is to the weed the more difficult it will be to find a herbicide which will give selective control. In developing countries, like Ethiopia, where machinery and chemicals are lacking, and labor is available, weeds must be pulled by hand or destroyed with very simple roots. Cultural practices like, use of fertilizers, time and method of planting, and correct rotation of crops also suppress the weed population. For best results, a combination of one or more of the aforementioned weed management practices (methods) should be applied in fruit crops production to obtain the best results.

Plant diseases management

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

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

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

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

The management measures include:

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

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

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

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

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

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

Nematodes management

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

Various methods are available to reduce crop losses from nematodes:

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

Insect management

Insect pests may be classified according to the way they feed on plants. In general, there are two groups (Edmond, 1983):

- those with biting mouth parts and;
- those with sucking and/or rasping mouth parts.

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

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

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

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

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

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

Management measures

The management methods for harmful insects are four types.

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

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

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

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

Vertebrates

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

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

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

CHAPTER 5: HARVESTING, POST-HARVEST HANDLING AND MARKETING OF FRUIT CROPS

5.1. Harvesting

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

5.2. Postharvest handling (grading, storage, etc.)

After harvesting immediate post-harvest handling system is important. The three main objectives of applying postharvest technology to harvested fruits are:

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

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

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

Packing and Packaging Practices

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

Cooling Practices

Throughout the period between harvest and consumption, temperature control has been found to be the most important factor in maintaining product quality. Fruits, vegetables and cut flowers are living, respiring tissues separated from their parent plant. Keeping products at their lowest safe temperature (0 °C or 32 °F for temperate crops or 10-12 °C or 50-54 °F for chilling sensitive crops) will increase storage life by lowering respiration rate, decreasing sensitivity to ethylene gas and reducing water loss. Reducing the rate of water loss slows the rate of shriveling and wilting, causes of serious postharvest losses. Keeping products too cool can also be a serious problem. It is important to avoid chilling injury, since symptoms include failure to ripen (bananas and tomatoes), development of pits or sunken areas (oranges, melons and cucumbers), brown discoloration (avocados, cherimoyas, eggplant), increased susceptibility to decay (cucumbers and beans), and development of off-flavors (tomatoes) (Shewfelt, 1990). Cooling involves heat transfer from produce to a cooling medium such as a source of refrigeration. Heat transfer processes include conduction, convection, radiation and evaporation.

If a ready supply of electricity is available, mechanical refrigeration systems provide the most reliable source of cold. Methods include room cooling, forced-air cooling and evaporative cooling. A variety of portable forced-air coolers have been designed for use by small-scale growers and handlers. However, a variety of simple methods exist for cooling produce where electricity is unavailable or too expensive. Some examples of alternative systems include night air ventilation, radiant cooling, evaporative cooling, the use of ice and underground (root cellars, field clamps, caves) or high-altitude storage. Another aspect to consider when handling fruits and vegetables is the relative humidity of the storage environment. Loss of water from produce is often associated with a loss of quality, as visual changes such as wilting or shriveling and textural changes can take place. If using mechanical refrigeration for cooling, the larger the area of the refrigerator coils, the higher the relative humidity in the cold room will remain. It pays however, to remember that water loss may not always be undesirable, for example if produce is destined for dehydration or canning.

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

Storage Practices

If produce is to be stored, it is important to begin with a high-quality product. The lot of produce must not contain damaged or diseased units, and containers must be well ventilated and strong enough to withstand stacking. In general, proper storage practices include temperature control, relative humidity control, air circulation and maintenance of space between containers for adequate ventilation, and avoiding incompatible product mixes. Commodities stored together should be capable of tolerating the same temperature, relative humidity and level of ethylene in the storage environment. High ethylene producers (such as ripe bananas, apples, cantaloupe) can stimulate physiological changes in ethylene sensitive commodities (such as lettuce, cucumbers, carrots, potatoes, sweet potatoes) leading to often undesirable color, flavor and texture changes.

Temperature management during storage can be aided by constructing square rather than rectangular buildings. Rectangular buildings have more wall area per square feet of storage space, so more heat is conducted across the walls, making them more expensive to cool. Temperature management can also be aided by shading buildings, painting storehouses white or silver to help reflect the sun's rays, or by using sprinkler systems on the roof of a building for evaporative cooling. The United Nations' Food and Agriculture Organization (FAO) recommends the use of ferrocement for the construction of storage structures in tropical regions, with thick walls to provide insulation. Facilities located at higher altitudes can be effective, since air temperature decreases as altitude increases. Increased altitude therefore can make evaporative cooling, night cooling and radiant cooling more feasible. The air composition in the storage environment can be manipulated by increasing or decreasing the rate of ventilation (introduction of fresh air) or by using gas absorbers such as potassium permanganate or activated charcoal. Large-scale controlled or modified atmosphere storage requires complex technology and management skills; however, some simple methods are available for handling small volumes of produce.