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ABSTRACT

This manual is intended for use by Peace Corps volunteers as a resource for gaining an understanding and knowledge of basic horticultural principles and practices of orchard management. Addressed in the individual units of instructional text are orchard soils; botany of horticultural plants; insect and disease control in orchards; pome, stone, citrus, vine, and tropical fruits; and nuts. Appendixes to the manual contain a series of practical exercises dealing with photosynthesis, plant reproduction, and transpiration. (MN)

Orchard Management

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ORCHARD MANAGEMENT:

HORTICULTURAL PRACTICES

FOR

PEACE CORPS VOLUNTEERS

Prepared for the United States Peace Corps

by

DEVELOPMENT AND RESOURCES CORPORATION

In accordance with Contract PC-25-1706,
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APPENDIX

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The preparation of this Horticultural Practices Manual for Peace Corps Volunteers has been accomplished with the cooperation and assistance of several individuals and organizations. The contributions of each of them are gratefully acknowledged: the technical staff of Development and Resources Corporation who developed and utilized some of the material in their training courses for Peace Corps Volunteers; various staff members of the University of California, Davis; and Mr. Robert Sappington, Horticulture Chemist, for his time and advice in reviewing the final preparation of the manual.

Special appreciation is expressed to Mr. Jack Frankel, Agriculture Specialist, United States Peace Corps, without whose vision, encouragement, and support this manual would not have been possible.

INTRODUCTION

This manual has been prepared for use by Peace Corps Trainees and Peace Corps Volunteers as a resource in gaining understanding and knowledge of basic Horticultural principles and practices of Orchard Management. Subject areas have been limited to those observed as being of most frequent concern to Volunteers in their project activities in fruit tree growing in agricultural programs abroad and particularly with deciduous type trees.

This manual is designed to convey insights into basic Horticultural practices and techniques. Primary emphasis is given to providing explanations and illustrations of Horticultural practices as they relate to fruit tree production. Care has been taken to make the content realistic and meaningful and presented with as non-technical a vocabulary as is possible.

The manual, to be most beneficial, should be used during training as a teaching guide and instructional tool. While the manual provides useful drawings, structural diagrams, and practical exercises, it is recognized that some of the material presented would be meaningless, or at least inadequately understood, by the average generalist or by the individual with no previous Horticulture experience. When the manual is utilized as an integral part of a training program in which trainees are being prepared for work in Horticulture, and the material contained herein is presented and explained to trainees by qualified Horticulture Specialists, the manual can and will continue to be a valuable reference source for the Volunteer in the field.

Each of the principle units of the manual is complete and substantially self-contained. Topic coverage is sequential but does not preclude each unit being used as a review or as new material. With the aid of this manual, during and after training, a Peace Corps Volunteer should be able to apply the principles and procedures of acceptable Horticultural practices on the farm for increased fruit tree production to almost any orchard management problem he might encounter during his service abroad.

Development and Resources Corporation sincerely hopes that Peace Corps Volunteers will find this manual a useful working tool and helpful in their project activities.

UNIT I - ORCHARD SOILS

A. A DEFINITION

To define a good or adequate soil for orchard production is to say that a given plot or area of land must possess the following qualities

1. A deep and well aerated soil with good drainage.

2. Adequate nutrients for optimum tree growth and high yields.

3. Good water holding capacity - the ability to store and feed the fruit tree with an abundant supply of water.

B. SOIL CLASSIFICATION

Physical Properties

Productive soils contain at least 50 percent pore space, which is made up of air and water in varying proportions.

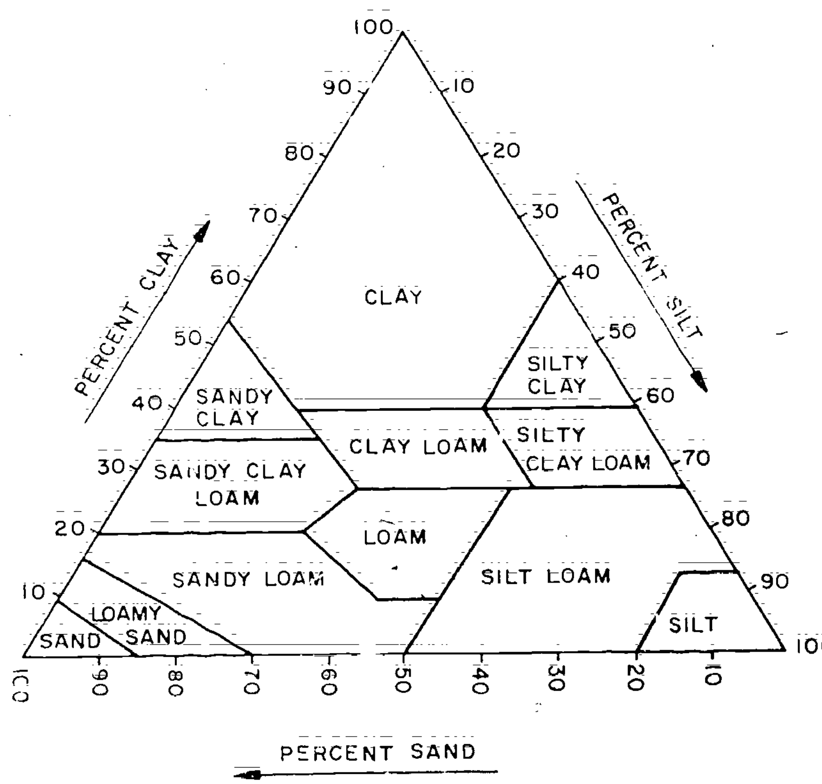
The composition of a soil is solely dependent upon the environment in which it has or is being formed. One type of soil is known as residual. In this, parent materials are derived from rocks that contain quartz, silicates such as feldspars, iron oxides, carbonates, and phosphate. In areas of the world where there is a heavy rainfall, many of the basic elements (calcium, magnesium, sodium, and potassium) in the parent material are leached away. These soils are usually acid. Where rainfall is lower, the parent materials are not leached as much and the soil is either neutral or alkaline.

Other types of soil may be formed from glacial deposits, or from what is known as wind-blown soils.

Orchard soils may have been derived from any of these sources. What is important to remember is that there is no one single orchard soil type that is particularly suitable for all needs. Recommended soil types will be explained later in this manual for certain fruit and nut crops. One should remember that soil types can cause great differences in yield. A good soil for farm crops may not necessarily be the best one for orchard cultivation. Likewise, other soils possessing good physical qualities but lower in nutrients may be found suitable for apple trees. There are many variables

In any soil, there are three very important characteristics which one should learn. They are referred to as the texture, structure and density of the soil.

Soil texture refers to the proportion of clay, silt, and sand particles in a given volume of soil. (Figure 1.) Since this aspect of soil properties is set by nature, man cannot change the texture of a soil, as he is able to do with the structure, which is explained later. Soil particles which exceed 2 mm are classified as gravel. Sand particles are the next largest (2.00 mm - 0.05 mm) in size. Sand has a gritty feeling when rubbed in the hand. Silt particles (0.05 mm - 0.002 mm) have a velvet-like feeling to the hand while clay (less than 0.002 mm) is the smallest size fraction and has a sticky feeling when moistened in the hand. Also, in most soils there are small portions of organic material.



SOIL TEXTURE TRIANGLE

FIGURE I

A soil texture classified as a "loam" consists of 28-50 percent silt, 25-52 percent sand, and 7.5-27.5 percent clay. A soil containing equal amounts of the three separates is a "clay loam".

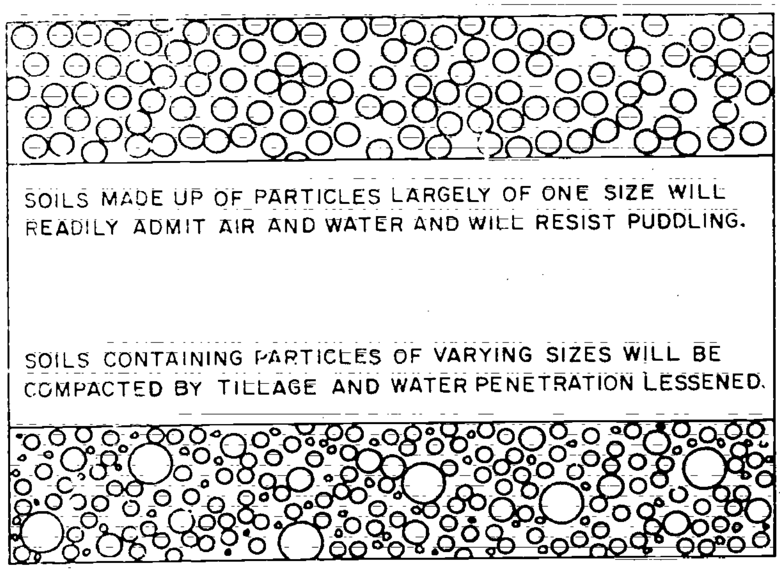
Various textures are indicated in Figure 1 and are grouped into three general categories; namely, coarse textured soils, medium textured soils, and fine textured soils.

Coarse textured soils: sands, loamy sands, and sandy loams
Medium textured soils: loams and silt loams
Fine textured soils: clay loams, silty clay loams, and clays

The fine textured or clay soils are known as heavy soils, and the coarse textured soils are known as light soils.

Soil texture has a large influence on the amount of water that can be stored in soils for plant use and the rate at which water moves through the soil.

Soil structure is a term used to describe the arrangement of the soil particles into conglomerates of many sizes. A point to remember is that a soil which is well-aggregated and falls apart or crumbles easily is generally desirable for orchards. This type of structure allows for good water penetration, soil aeration, and good drainage. As is not the case with soil texture, the structure may be enhanced by growing cover crops and adding organic matter such as cow manure.



DESIRABLE VERSUS PUDDLED SOIL
FIGURE 2

If a soil is high in clay content, wet, and compacted by working implements or animals, the pore space will be reduced considerably, thus creating a "puddled" soil. (Figure 2) This type of soil is not desirable in orchards and should be avoided.

Soil density refers to both "particle density" and "bulk density".

"Particle density" takes into consideration only the solid particles of the soil and not the pore space. It can be defined as weight per unit volume of soil particles and is usually expressed in grams per cubic centimeter.

"Bulk density" considers both the solid particles and the pore space of the soil. Therefore, it is variable due to different volumes of pore space existing in a soil.

Both types of densities serve to determine the porosity of soil or "pore space" according to this formula:

$$PS = 100 - \left(\frac{BD}{PD} \times 100 \right)$$

PS = pore space in percent
BD = bulk density
PD = particle density

The importance of the pore space percentage of a soil determines the amount of water the soil can hold.

C. SOIL FERTILITY

Soil fertility refers to the nutrient supplying properties of the soil. Trees, like any other living thing, need food if they are to live and grow. If they are well fed, they will generally grow faster, stronger, and, therefore, be somewhat resistant to insects and diseases and will usually give a good yield. If they are poorly fed, they will grow slowly, become weak or generally susceptible to insects and diseases, and produce low yields.

There are sixteen elements which are essential for normal fruit tree growth and development. These are: carbon, hydrogen, oxygen, iron, manganese, copper, nitrogen, phosphorous, potassium, zinc, boron, molybdenum, calcium, magnesium, sulphur, and chlorine. Carbon, hydrogen and oxygen are usually obtained by trees from water and air. Nitrogen, phosphorous and potassium are called primary food elements.

Calcium, magnesium and sulphur are called secondary food elements. Boron, manganese, copper, zinc, iron, molybdenum, and chlorine are called micronutrients, or elements needed in very microscopic amounts.

Carbon - This comes from carbon dioxide of the air. It functions in the plant or tree helping to build cell walls. It is a component of plant and tree sugars, a part of the structure of color, and even an element in the fragrance of fruit tree blossoms.

Hydrogen - One of the two elements composing water. This element is essential in the fruit tree with carbon and oxygen. It is used in the plant cell in the manufacture of simple sugars and starches.

Oxygen - One atom of this element combined with two atoms of hydrogen forms water. Oxygen also combines with other elements to form oxides and complex organic compounds.

Primary food elements:

Nitrogen - Nitrogen is the essential element for building growth materials in the tree. It promotes vegetative growth and gives trees a healthy, green color. It improves fruit set and overall fruit quality.

Phosphorous - Phosphorous is essential to all tree growth and is an active ingredient of protoplasm. It stimulates early growth and root formations, hastens maturity, promotes seed production and fruit development, gives stability to the stem, and contributes to the general hardiness of trees.

Potassium - Potassium enhances the tree's ability to resist disease, cold, and other adverse conditions. It also promotes good growth, blossoming, and fruit set.

Secondary food elements:

Calcium - Calcium is believed to help in the translocation of carbohydrates in the fruit tree. It is considered essential to healthy cell walls and aids in the development of root structure. Calcium is the active element in liming materials used to correct soil acidity and it also occurs in gypsum which is used in the treatment of saline and alkali soils.

Magnesium - Magnesium is an essential ingredient of chlorophyll and aids in the translocation of starch within the fruit tree.

Sulphur - Sulphur is associated with plant protein. It also aids in the synthesis of oils.

Micronutrient elements:

Boron - Boron is associated with calcium utilization within the plant. Whenever the proportion of calcium to boron becomes unbalanced because of a deficiency of boron, the terminal part of the tree fails to develop properly. The amount of boron required by trees is usually small.

Copper - Copper is an activator or catalyst of other elements within the plant. It seems to promote the formation of Vitamin A and appears to have a regulating function if soil nitrogen is too high. An excess of copper is very toxic.

Iron - Iron is essential for the formation of chlorophyll. Iron apparently enters into the oxidation processes which release energy from sugars and starches.

Manganese - Manganese is closely associated with copper and zinc and also acts as a catalyst in plant growth processes.

Molybdenum - Molybdenum is associated with nitrogen utilization. Very small amounts are needed.

Zinc - Zinc is apparently linked with iron and manganese in the formation of chlorophyll and fruit bud formation.

Chlorine - Chlorine is the latest element established as essential for plant growth. It is believed to stimulate the activity of some enzymes and to influence carbohydrate metabolism or the production of chlorophyll and the water-holding capacity of growth tissue.

We speak of food elements removed from the soil by fruit trees. The three elements -- nitrogen, phosphorous, and potassium -- which have been termed primary elements are also called the fertilizer elements are indicated by the symbols N, P, and K. Thus, a fertilizer is termed a complete fertilizer when it has these three elements -- N, P, and K -- in its formula. These three elements are all needed by fruit trees in substantial quantities. Each must be furnished to the tree from supplies in the soil or added to the soil by manures or chemical fertilizers. The so-called micronutrient elements are needed by fruit trees in comparatively small amounts and are usually present in soils in quantities sufficient to meet the needs of the tree. This is not invariably so but these nine elements are much more rarely deficient than are the three fertilizer elements -- nitrogen, phosphorous, and potassium -- whose lack often limits fruit tree production. It is with these elements that the orchard manager is most often concerned. It is generally the quantities of these three elements in the soil which determine its fertility.

The needs of different fruit trees for these elements vary. One tree may require much more nitrogen; another may require more phosphate. Generally speaking, the higher the yield of a fruit tree crop, the greater the demand for all the necessary elements.

Deficiencies apparent with the three primary elements may be overcome with the addition of commercial fertilizers. Although fertilizers will be explained later in this manual, it is well to include in this section the subject of cover crops due to its direct relation to soil fertility.

A cover crop is termed as any viable crop, including weeds, grown between the trees and plowed under in an orchard. The purpose of growing a cover crop is to add organic matter to the orchard soil to provide additional nitrogen and maintain good soil structure. A cover crop aids in water penetration into the soil, and to some extent guards against "puddling" by the activity of its root system. This is particularly true in tropical wet areas.

"Puddling" would be reduced because the cover crop would help considerably in "breaking" the force of heavy rains against the soil; thus compaction of the soil would not be such a problem.

Even though there are many advantages of growing cover crops, they can also cause damage in certain areas of the world. In regions where there is low rainfall, the trees need all the available moisture for growth. A cover crop in this area would compete with the trees themselves for the available mosture; thus, a cover crop would not be recommended.

Cover crops recommended for use according to various areas of the world are:

1. Cold climates - red clover, mustard, common weeds of the area and field peas.

2. Warm climates - cereal grasses, such as rye and barley, field peas, certain varieties of mustard (according to the area), and cowpeas. Also orchardgrass and sudangrass.

D. SOIL AND WATER RELATIONSHIPS

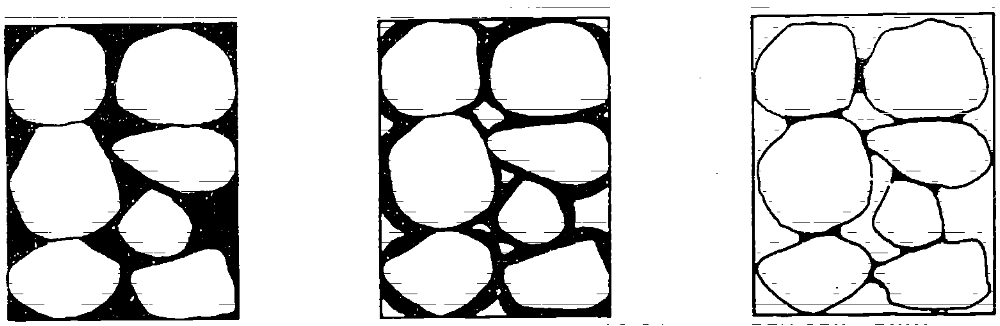
Available Moisture for Growth Processes

Water may be classified as unavailable, available, and gravitational or superfluous. If water is applied to a soil until all of the poor space is filled, the soil is said to be "saturated". About one-half of this moisture will be lost due to the pull of gravity. Usually this gravitational water has drained away within about 24 hours following application. Except for rather slight losses due to evaporation from the soil surface and continuing drainage due to gravity, the soil moisture remaining indicates the "field capacity" of that soil. (Figure 3.)

In practice, field capacity is usually determined two days after an irrigation. A soil will come to field capacity more quickly when an active crop is growing than when there are no roots removing water from the soil.

Field capacity can be measured by determining moisture content of soil after irrigation sufficiently heavy enough to ensure thorough wetting of the soil. Observing the decrease in moisture by making moisture determinations at different times after irrigation is valuable in understanding and properly interpreting the field capacity characteristics of a soil.

If there are plants or trees growing on the soil, the moisture level continues to drop until the "permanent wilting point" (p. w. p.) is reached. Soil moisture content near the wilting point is not readily available to the tree. Hence, the term "readily available moisture" has been used to refer to that portion of the available moisture that is most easily extracted by the tree, approximately 75 percent of the available moisture. After this point, the tree is unable to absorb water from the soil quickly enough to replace water lost by transpiration.



SATURATED SOIL: UNSATISFACTORY FOR ROOT GROWTH

SOIL AT FIELD CAPACITY: LARGE AMOUNTS OF WATER BUT ENOUGH OXYGEN FOR GROWTH

DRY SOIL: ONLY HYGROSCOPIC AND LITTLE CAPILLARY WATER LEFT — TOO DRY FOR ROOT GROWTH

MOISTURE AVAILABILITY
FIGURE 3

The soil moisture content when plants permanently wilt is called the permanent wilting point or the wilting coefficient. The permanent wilting point is at the lower end of the available moisture range. Tree leaves will wilt when they are no longer able to extract sufficient moisture from the soil to meet their needs. Wilting depends upon the rate of water used by the tree, the depth of the root zone, and the water holding capacity of the soil. Tree growth should usually not be retarded by lack of available soil moisture. The practice of withholding irrigation until the fruit tree definitely shows a need for water is likely to retard growth. It is essential to maintain readily available water in the soil if fruit trees are to make satisfactory growth.

Water Uptake By Trees

Water is important for tree and plant growth because it assists in absorption of mineral nutrients and is in itself necessary for growth.

Water is taken in through the root system by the process of osmosis (diffusion pressure deficit) and likewise is mainly lost through its leaves by the process of transpiration.

Osmosis means the movement of a liquid (water) through a semi-permeable membrane (root) from an area of high concentration (outside of root) to one of lesser concentration (interior of root membrane). Since the pressure is greater on the outside than the inside of the root system, water molecules "pound" against the root, thus entering the root because of less inside pressure. The water entering the root is entirely pure and does not contain any other dissolved materials in it.

Transpiration means the evaporation of moisture from plant surfaces or leaves. Plant or tree leaves may contain as high as 90 percent moisture content. This high percentage is necessary because water is constantly being lost by evaporation from the cells in the leaves. Trees do lose water through parts other than leaves, but it is minimal in comparison. Loss of water from the leaves takes place in the "stomata" -- tiny "stomates" or structures found on the underside of leaves. These stomates open and close according to the amount of light intensity. When there is no sunlight, the stomates close and there is very little transpiration loss. In a leaf cell, a stomate follows a passage which leads to a sub-stomatal air chamber. The soft spongy tissue surrounding the air chamber is bathed in water which absorbs the carbon dioxide from the air trapped in the air chamber. Since the soft spongy tissue is constantly evaporating water into the air chamber, there is a movement of water vapor into the outer atmosphere by diffusion through the stomata, thus, transpiration occurs.

The quantity of water lost is great. There are a number of external factors which greatly influence the rate of transpiration such as:

1. Low humidity - causes faster transpiration

2. High temperature - causes faster transpiration

3. Cool humid wind - causes slower transpiration

4. Hot humid wind - causes faster transpiration

In practical terms, transpiration loss means that one should always make sure there is a good balance of available water to the root system in relation to the environment so as not to allow a continual deficit to occur and thereby retard growth, fruit set, etc. If there is a high transpiration rate occurring, the deficit is corrected by drawing water from other parts of the tree and finally reaching to the bottom of the root system. If the root system depletes all of the available water supply, then the tree will wilt and eventually die unless water is restored to the soil.

Irrigation of Orchards

The purpose of irrigation is to keep the soil supplied with readily available moisture. There are three principal irrigation methods used for orchard trees. They are referred to as furrow, basin, and sprinkler irrigation.

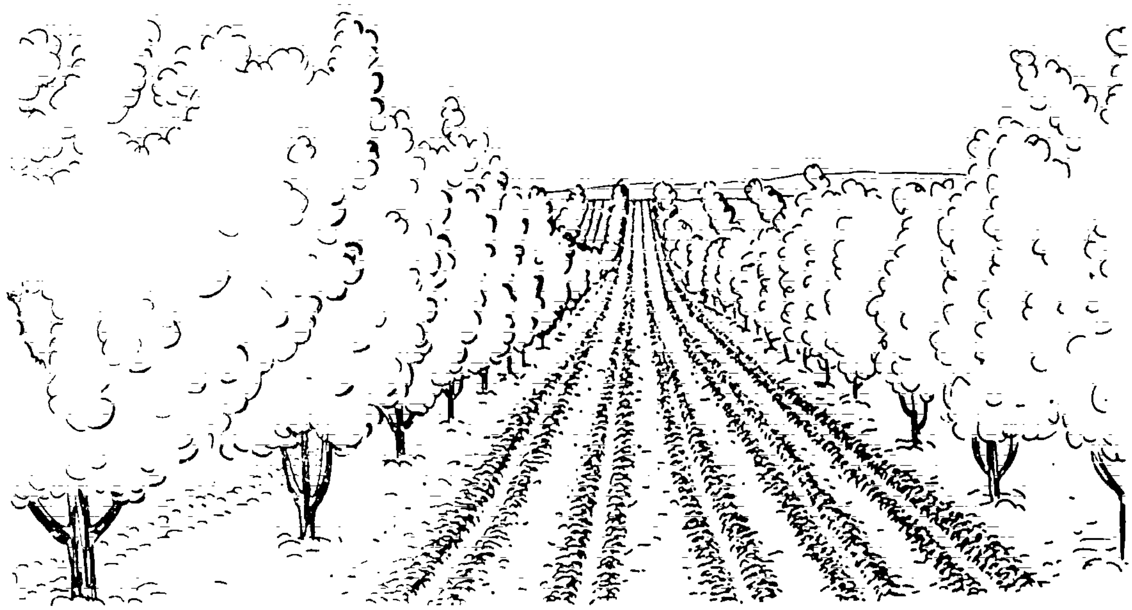
The furrow method (Figures 4, 5, and 6) is good as long as the slope of the land and the size of the water stream are such that erosion does not occur. The furrows should be constructed so that they are close enough together allowing the wetted areas to meet and to hold water long enough to allow penetration into the soil to the desired depth.

The basin method (Figure 7) or rectangular checks refers to levees constructed around an individual tree or trees in the orchard. This method allows for application of water over the entire soil surface of the orchard, but may require more labor in its initial construction in comparison to furrows.

The sprinkler method (Figure 8) is ideal for sloping, rolling or steep orchards. This method needs no leveling and usually gives a uniform watering of the soil.

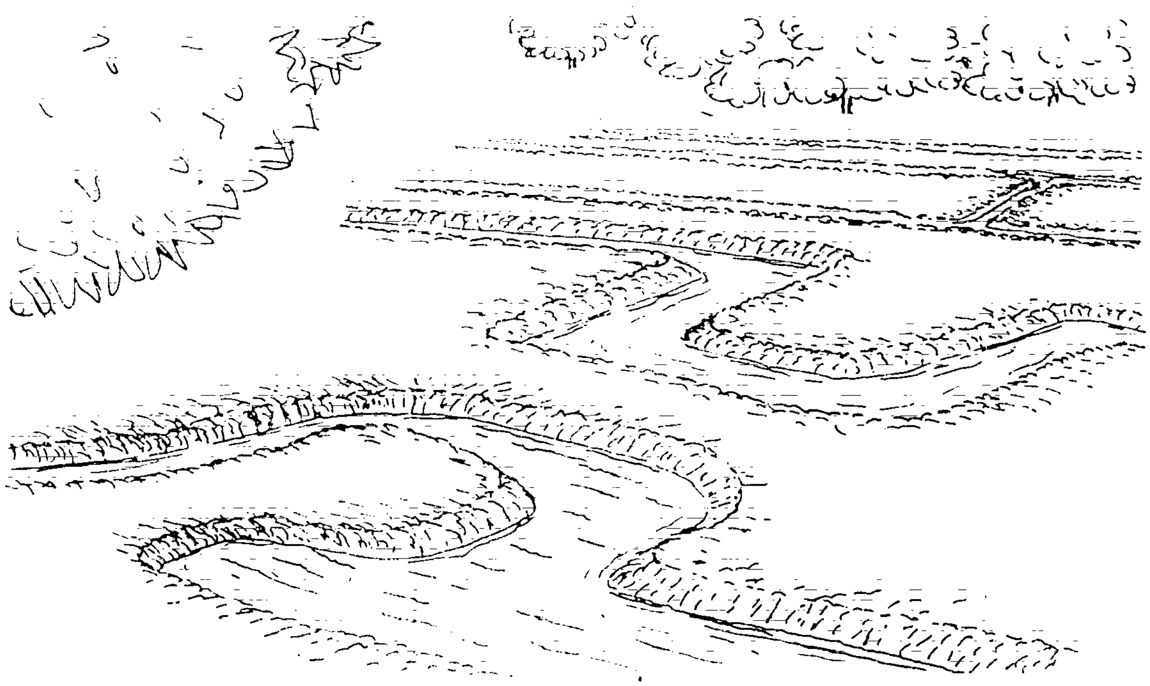
However, due to high investment and maintenance costs it may be found to be prohibitive in certain developing countries, although a few systems are in use in these areas where agricultural development is taking place.

All three methods may be used and will give satisfactory results. Due to cost differences, the first two will probably fit the needs of a developing country more so than the third method.

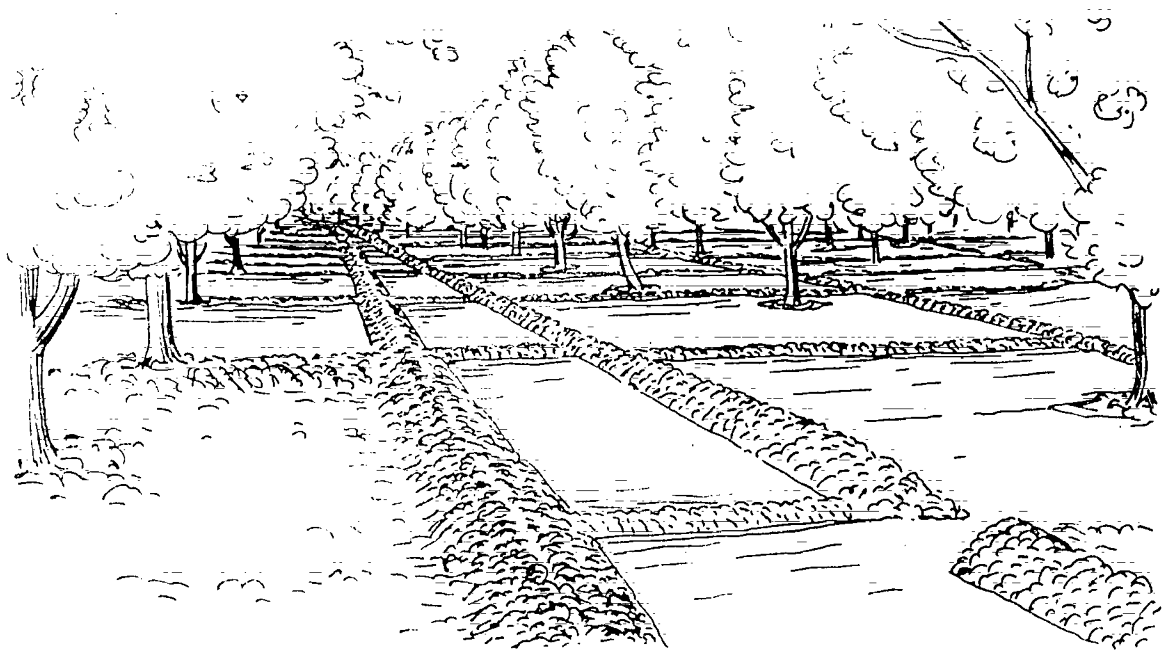


STRAIGHT FURROWS
FIGURE 4

CONTOUR FURROWS
FIGURE 5



ZIGZAG FURROWS
FIGURE 6



RECTANGULAR OR BASIN CHECKS
FIGURE 7

SPRINKLERS
FIGURE 8

The amount of time needed to adequately irrigate an orchard would be based on many factors such as soil types, rainfall, availability of water, temperature, etc.

Obviously, trees will require more water during the growing season due to leaf formation, flowering and fruit set. An easy rule of thumb to follow in judging water needs is to observe the broad-leafed weeds which may be present in an orchard. Since this type of weed is generally deep-rooted, any sign of wilting would mean that water needs to be restored to the soil as the tree roots would also be in need of water. The point to remember is never to let the orchard reach a severe wilting point stage.

Adequate drainage has already been stressed as essential for fruit tree growth because without it, available pore space in the soil would be saturated and there would be restricted root growth due to lack of oxygen.

Cultivation of orchards is important because it helps to control noxious weeds. Eradication of weeds is impossible but control is possible. By controlling weeds through cultivation practices, several useful purposes are served:

1. Allows for easier irrigation, harvesting and spraying

2. Helps prepare soil for a cover crop (other than weeds)

3. Helps control certain pests and insects

If weeds are used as a cover crop, especially during the growing season, they may become serious competitors with the trees for moisture and nutrients. This competition can be removed through cultivation.

Cultivation will also allow for ease in irrigation by allowing "cleaner" construction of furrows or basin rectangular squares.

Through cultivation a sometimes viable environment or "home" for insects may be destroyed.

Contrary to common belief, cultivation does not conserve moisture. It may allow for greater water penetration into the soil, but this is of a temporary nature.

E. SOIL AND PLANT (TREE) RELATIONSHIPS

pH factor

In chemistry, reaction of solutions is usually stated in terms of pH which is an expression of active acidity or alkalinity. A pH of 7.0 is known as a neutral soil. When a pH exceeding 7.0 occurs, then we have what is known as an alkaline soil. A pH which is lower than 7.0 approaches acidity, or acid soil. Deciduous fruit trees, those which shed their leaves during dormancy, can tolerate wide ranges of the pH spectrum. There will be little attempt to recommend proper pH ranges for various fruit trees due to so many variables. It is important to remember that some fruit trees cannot tolerate certain acid soils and, likewise, alkaline soils. It is also important to remember that the pH of a soil can be altered by the addition of commercial fertilizers making it more suitable for root development. For example, to lower the pH, one may add ammonium sulfate (source of nitrogen). This may benefit trees which require a slightly more acid soil. To make soils more alkaline in nature, sodium nitrate, lime or calcium nitrate may be added.

F. SOIL ORGANISMS

Organic matter by itself would be useless in the soil without billions of tiny soil organisms breaking it down into humus and then into simpler products utilized by plants and trees. Of all organisms present in the soil, bacteria makes up 90 percent of the total.

Organisms found in soil are either classified as plants or animals. Some are so small only a microscope can bring them into view. Others are much larger and better known to the average person, such as the earthworm. Also, some organisms are beneficial to the soil and, therefore, the plant or tree, while others do great harm. On the whole, there is more benefit than harm derived from soil organism activity. Some of these benefits are found in the decomposition of organic matter and making nitrogen more readily available to the roots. Some of the harmful aspects include those which cause plant diseases and those which compete for available nutrients with the plant itself.

The activities of soil organisms are regulated by such factors as temperature, acidity or alkalinity of the soil, moisture, light, and organic matter.

For purposes of orchard management, several common soil organisms worthy of mention are:

Bacteria - single-celled plants

Fungi - yeasts, molds and mushrooms, considered to be a plant

Algae - microscopic plants; found in surface layers of soil

Protozoa - considered to be an animal of the simplest form, larger than bacteria, but still microscopic in size.

Nematodes - animals and wormlike in appearance

Earthworms - animals and known as the common earthworm

Of the six organisms mentioned, nematodes cause the worst damage in orchards because they infest the root system and cause injury. Swellings of roots may occur.

G. FERTILIZERS

Although stress has been placed on understanding the soil as an important factor in achieving maximum production, it is important to understand nutrient deficiencies in soils, and the best way to correct them.

Not all soils are deficient in essential elements. Some lack only a few of the elements. Other soils have been fortunate in having a high percentage of organic matter present due to cover crops and animal manure, which has been broken down by soil organism activity.

Fruit trees, like most plants, begin to deplete the soil of its essential elements, particularly nitrogen, phosphorous, and potassium through sustained growth. To replenish the soil, inorganic or commercial fertilizers are most commonly applied to maintain growth and production. Obviously, the need arises in determining what deficiencies exist. There is no foolproof method of determining these factors; however, there are four methods used in orchard management that assist in implementing a fertilizer program.

Tree symptoms - Most widely used method in detecting nutrient deficiencies. Some of these symptoms may include pale green leaves, slow or weak growth, abnormal leaf size, no flower bud formation, dropping of flowers or fruits, poor fruit color, etc. This method is very practical when determining deficiencies for each element (to be discussed later).

Orchard plot trials - After a soil analysis has been taken and deficiencies are apparent, it may be desirable to try several fertilizer trials on a limited area of the orchard. It should be done carefully and over several seasons of duration in order to determine whether the addition of nitrogen, phosphorous, potassium, etc., in various amounts has increased yield and done so profitably. This method may prove too costly in a developing nation for the average farmer. However, research centers and agricultural universities may find it useful.

Soil analysis - This method is mentioned because analyzing a soil for available nutrient content is an accepted practice worldwide and proper facilities, chemicals, etc., are available in most developing countries to conduct such an analysis. However, unless the soil sample taken for an analysis is from the general area of the deep root system and representative of the area, the results will be close to worthless -- the reason being that soil above or below the general root zone of the orchard tree may possibly have an entirely different soil structure containing different amounts of essential elements and may not be available to the tree roots at these various depths. Where soil analysis alone has been found to be a good method in determining fertilizer needs for plant growth, orchard management has not found this to be true. There are too many variables with the many fruit trees, particularly due to varying depths of the root system. If used in orchard management, it should be done in addition to tree symptoms to give an overall assessment of fertilizer needs.

Leaf analysis - This method is the newest form in determining fertilizer needs. It is mentioned only because of its latest developments since leaves themselves, more than any part of the tree, require the essential elements for growth. Under examination of the leaf cells, one can determine if they are receiving enough of any one element. Although this method is very scientific in approach, inexpensive methods are being adopted for orchard management in several parts of the world.

What does all this mean in terms of a practical approach of determining fertilizer needs for fruit trees? Use the tree symptom method. By knowing what deficiencies of the essential elements will show to the naked eye, fertilizer recommendations can be made. To do this, a complete fertilizer must be considered. As stated earlier, a complete fertilizer consists of nitrogen, phosphorous, and potassium. This is the form in which commercial fertilizers are usually sold and in varying amounts of each. Usually, these fertilizers will contain small amounts of the micro-nutrients (zinc, copper, etc.), but not readily available to the trees. Nitrogen is the most important element as a fertilizer for trees and, therefore, receives the greatest attention by orchard growers. Although it is made available to the trees through organic matter, inorganic types are used more widely because of ease of application and a higher percentage of total N (nitrogen) available in most fertilizers. Nitrogen deficiencies are indicated by pale, yellowish-green leaves in early to mid-summer; short vegetative shoots, usually small in diameter; heavy bloom with a heavy loss of bloom, and results in a poor crop by small fruit maturing early and dropping from trees too early. When nitrogen is supplied, the first response will be an improvement in leaf color and better growth. After a season or two full development should have occurred and more production reached. This time cycle may last for four to five years, after which another application will have to be made.

The rate of application of nitrogen is indeed difficult to place on [illegible]. However, it must be based on such factors as tree condition, kind of fruit, age of tree, water supply, soil condition, etc. For example, young trees on a soil initially quite fertile, could grow well showing no nitrogen deficiency, but after several years of bearing fruit, deficiencies may occur. The supply of nitrogen in a light soil is limited, and becomes depleted sooner than on a heavier soil.

In general, trees with a weak growth because of lack of nitrogen should need up to 60 to 100 pounds of actual nitrogen per acre -- 300 to 500 pounds of ammonium sulfate, or 360 to 600 pounds of calcium nitrate per acre. Higher rates are not necessary and not profitable. Most fruit trees will require considerably less to bring them to full production. The application should be made in early spring and no more than once a year.

Phosphorous depletion is usually from one-eighth to one-tenth the amount of nitrogen on the same land and from the same trees. Phosphorous is important to trees and its deficiencies are similar in nature to those of nitrogen. Reduced growth is one symptom. To distinguish phosphorous deficiency symptoms from nitrogen deficiency symptoms, darker green leaves than normal may appear in early to mid-summer as contrasted to light green leaves with a nitrogen deficiency. In late summer and fall, the leaves may turn to a bronze or purplish-red color, in contrast to light

PRINCIPAL COMMERCIAL SOURCES OF NITROGEN FOR ORCHARDS

NAME	Compound Formula	Percent Nitrogen	Advantages	Disadvantages*
Anhydrous Ammonia	NH_3	82.0	High nitrogen percentage; ease of application; no residue; little danger of leaching.	a) Irrigation water; uneven distribution if irrigation system not adapted to its use. Cannot be used with sprinklers. b) Dry injection; some loss if ground is trashy or cloddy.
Ammonia Solution	NH_4OH	Usually 20.0	Easier to handle than anhydrous; no residue.	Same as for anhydrous.
Ammonium Sulfate	$(NH_4)_2SO_4$	21.0	Acid residue (for alkaline soils); little danger of loss by leaching; ease of handling.	Acid residue (for very acid soils). Delayed availability during nitrification.
Ammonium Nitrate	NH_4NO_3	33.0	High N percentage; no residue. Half immediately available, half delayed.	
Ammonium Phosphate Sulfate (16-20) Mixture		16.0	Same as ammonium sulfate. Carries phosphate if needed for cover crop.	Same as ammonium sulfate.
Ammonium Phosphate	$NH_4H_2PO_4$	11.0	High phosphate content where needed for cover crops.	Low N percentage.
Calcium Nitrate	$CA(NO_3)_2$	15.5	Calcium residue (for acid or high sodium soils). Immediate availability.	May be leached.

NAME	Compound Formula	Percent Nitrogen	Advantages	Disadvantages*
Urea	NH_2CONH_2	42.0	High N percentage. Is not fixed if irrigated at once before conversion to ammonium carbonate. No residue.	May be toxic in high concentrations.
Sodium Nitrate	$NaNO_3$	16.0	Alkaline residue (for acid soils). Immediate availability.	Sodium residue undesirable on high sodium soils. May be leached.
Calcium Cyanamide	$CaCN_2$	24.0	Alkaline residue (for acid soils). Calcium residue.	Danger of burning, especially at high rates or in growing season.

*There is no serious trouble with the physical properties of any of these materials unless they are stored too long or under poor conditions.

red or pink leaves in nitrogen deficient trees. Phosphorous may be applied to the soil in the form of ammonium phosphate, or it may be applied in the form of superphosphate. The first is added at the same time as nitrogen and the second is applied when a cover crop is planted at the rate of 50 to 100 pounds per acre.

Potassium depletion may amount to about 20 to 35 pounds per acre per year. Deficiency symptoms may be apparent in leaf injury whereby there will be a scorching along the midrib or main veins during early to mid-summer. Some species of fruit trees will drop all of their blossoms or young fruit. In late fall, some of the growth shoots may die back.

Response to potassium fertilization can be slow in comparison to nitrogen and phosphorous applications. However, there is no question of the value of potassium for tree growth. This can always be substantiated by taking a leaf analysis.

For general purposes, potassium is usually applied in the form of potassium sulphate or potassium chloride (muriate of potash). Both contain about the same amount of potassium available for tree use. In most soils, no more than 400 to 500 pounds per acre of either form will be necessary.

Other important elements necessary for fruit trees - Although there are other elements necessary for good tree growth, flower set, and fruit formation, only those of greatest importance will be listed in detail. Certain fertilizer recommendations and application methods for each element are given as well as some deficiency symptoms.

Boron deficiency symptoms include death of terminal buds; scorching of leaf tips; reduced fruit set. In apples and pears, the fruits' flesh may become hard, brown and corky. Deformed fruit will occur.

A source of boron is from borax (sodium borate) and can be applied at the rate of 30 to 50 pounds per acre during the spring and fall. It should be broadcast on top of the soil, directly under the trees.

Molybdenum deficiencies sometimes are serious with citrus trees causing "yellow spots" between veins on older leaves in the summer. On some trees, all leaves may fall. Sodium molybdate at 0.1 ounce per tree in spray form should help in correcting this type of deficiency.

Manganese deficiencies may be seen as yellowing occurring in areas between veins of leaves. In some cases, the areas die and leaves fall prematurely. Unlike some elements, this deficiency may not prevent fruit set and normal development. Loss in yield would come from less total bearing surface of the tree.

This type of deficiency may be corrected by spraying a mixture of [illegible] to 8 pounds manganous sulfate and 5 pounds lime and a spreader per 100 gallons of spray. This mixture should be sprayed in late spring or early summer. Broadcasting is not satisfactory because the chemical is fixed (not available for growth) in most soils.

Magnesium deficiencies are much the same as for potassium. Discolored blotches may appear on leaves in mid-summer. Replenishment can be made by applying magnesium sulfate (epsom salts) or dolomitic limestone directly to the soil at the rate of 10 to 40 pounds per tree.

Zinc deficiency symptoms include yellow streaks in the leaves between the veins; narrow, undersized and stiff leaves in the spring are also a good indication. This disease is called "little leaf".

To overcome zinc deficiencies, use zinc sulfate by spraying at the rate of 50 pounds per 100 gallons of water. Application should be made directly to the soil for sweet cherry and walnut trees. Both applications should be done during dormant season or in early spring or fall. Caution: Under certain conditions, early spring or fall applications may cause dropping of leaves.

Iron is required much more than zinc or copper in tree growth, mainly for chlorophyll formation. Lack of iron causes yellowing of leaves [illegible] and sometimes a complete loss of green color. Iron is not [illegible] in soil, but may be made unavailable due to an excess of [illegible] the soil.

To economically replenish iron to the fruit tree, it is best to drill holes [illegible] the trunk of the tree and apply ferric citrate powder in the holes at the rate of one-tenth ounce per hole in large trees and one-twentieth ounce per hole in smaller trees.

Copper deficiencies are not too common, but when they occur, it usually is in the mid-summer season when the leaves become brown at the tips and many fall from the tree. Copper deficient trees may ultimately become dwarfed in appearance. The safest method of adding copper to the tree is by applying copper sulfate in a trench about four to eight feet from the tree at the rate of 5 to 20 pounds per tree.

Other elements necessary for the growth, etc., are sulphur, chlorine, sodium, and calcium.

Unless otherwise stated, there are five principle methods of applying the essential elements to fruit trees for best results. The practicality of each method is determined by the element in question and by what objectives are being sought in a fertilizer program.

1. Spreading of fertilizer around the tree - This method is desirable in applying a narrow band of fertilizer in a circular direction reaching out to most of the root system through the "leaching down" of the elements to a small percentage of the roots. A fairly concentrated fertilizer would be required with this method.

2. Fertilizing deep into the soil - This system is good if certain elements are found to be unavailable to the tree. By digging several deep holes around and near the root system, and filling the holes with fertilizer, at least some of the elements would become available to the roots. This is particularly true with potassium and phosphorous. Nitrogenous fertilizers used with this method should be done with caution due to the possibility of too great a concentration of nitrogen in certain areas of the root zone causing early maturing of fruit.

3. Fertilizer in irrigation water - If fertilizer and water are applied at the same time, this method may be desirable by using soluble compounds in the irrigation water.

4. Through holes in tree trunks - This method has briefly been recommended for several of the elements. This method is desirable for orchards where the soil is such that if certain elements were applied directly in the soil, they would not be available to the tree. Avoid using this method during the growing season.. Wait for the dormant season, if at all possible.

5. Spraying - A good method for certain micronutrients because of quick response to readily available elements in comparison to availability in the soil.

UNIT II - BOTANY OF HORTICULTURAL PLANTS

A. CLASSIFICATION

The common classification of horticultural plants or fruits includes fruits, vegetables and ornamentals plus medicinal plants. However, the horticulturist finds it necessary to further classify his field in more detail based on growth habit and similarity of plant parts. This type of classification is broken down into three main subdivisions.

Annuals

Annual plants are those which in the course of one year grow, flower, and produce seed to complete its life cycle and then dies. One year is the maximum amount of time required to complete the cycle. However, even though garden vegetables (beans, peas, etc.), weeds, and ornamentals usually require three to four months for this cycle, they are still considered to be annuals. Tomatoes, for example, may actually be prolonged in growth in a greenhouse for more than a year but are still considered an annual. On the other hand, it is possible for certain annuals to become perennials (live more than two years), if they are growing in a frost-free climate and are not susceptible to "frost-kill". Thus, the term "annual" is a highly flexible term.

Biennials

Biennial plants are those which need parts of two full years to complete their life cycle. This means a plant grows vegetatively one year and produces seed the next year. This is true of the carrot, beet, onion, and cabbage. However, most people convert these "biennials" into "annuals" by harvesting their roots or leaves the first year. Cultural practices, in this case, are the factors affecting the classification. It is only when these plants are grown for seed that they are considered "biennials". Although, not a horticultural plant, "winter wheat" is a true biennial since it is planted in the fall of one year and harvested during the next spring. The term biennial, as with annual, is quite flexible.

Perennials

Perennials are those plants which normally live for more than two years. The perennials are divided into two groups called herbaceous and woody.

Herbaceous perennials are those plants possessing soft and succulent stems. In certain climates, the tops or vegetative growth of the plant will die down after one season of growth. However, the roots often remain alive and are able to produce new shoots and growth the following season. These tops may be considered annuals, and the bottoms perennials. Such plants as asparagus, rhubarb, poppy and tulip are termed herbaceous.

Woody perennials are known as trees, shrubs, and vines. This is because their top growth usually remains woody in nature, even during dormant periods. Such perennials are usually upright in growth and the stems or trunks are the main axis from which smaller shoots or branches originate. Others may have no main axis and many different stems originate from the crown (surface of root system) forming shrubs.

Woody perennials, specifically fruit trees, are what we are chiefly concerned with in this manual.

To distinguish between fruits, vegetables and ornamentals, it is good to remember that the term "fruit" is used when a plant's fruit is eaten versus a "vegetable" meaning when the leaves or roots of a plant are used for food. Worldwide, these two terms are used slightly different; thus, in the United States, the tomato is commonly called a vegetable, whereas other countries may call it a fruit. In general, the two definitions stated are correct for most of the world.

"Ornamentals" are simply plants grown for their ornamental value. This term may conflict with fruits, as in the case of grapes, which are not always grown for their fruit, but for ornamental reasons, as well.

An important factor to remember is that, in general, classification of horticultural plants is largely determined by cultural practices of the world as well as the purpose for which they are being grown.

B. ANATOMY OF PLANT GROWTH

Anatomy of plant growth refers to its structure. Structure refers to tiny cells in plants which combine and form tissue and further combine and form plant organs. These organs are known as roots, stems, leaves, flowers, fruits, and seeds.

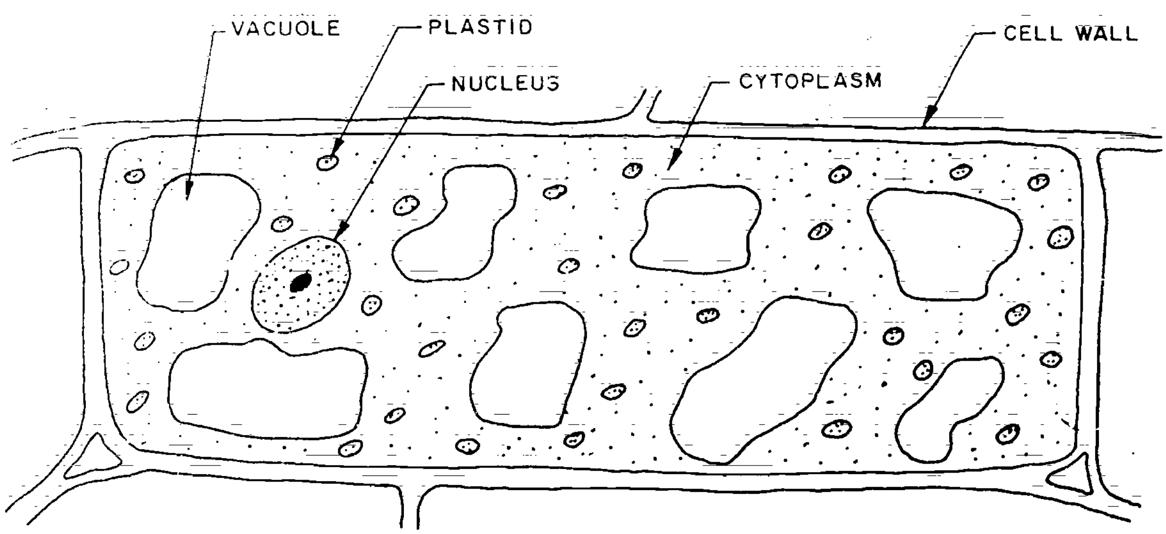
Cells are rectangular in shape and inside the cell wall there is a substance known as protoplasm. In the protoplasm itself, there is cytoplasm, vacuoles, a nucleus, and plastids. The nucleus is the most important part because it carries thread-like structures (chromosomes) which divide into more cells allowing for growth and carrying on hereditary characteristics. Around the nucleus is a gelatine-like material (cytoplasm) which aids in the movement of nutrients. Within the cytoplasm are found plastids which contain starch, fats, proteins and pigments. The green color in leaves is created by the chlorophyll contained in the plastids. These are called chloroplasts which together with the sun's rays produce sugar from carbon dioxide and water. This process if known as photosynthesis. Also, in cytoplasm are found vacuoles, which contain a substance known as cell sap. (Figure 9.)

There are several types of cells which are important in understanding plant growth.

Parenchyma cells are the simplest and also the greatest in number. These cells contain protoplasm and divide easily. Parenchyma cells are found in great numbers in roots and stems, particularly in young growth. They are also prevalent in other organs of plants and can stretch easily allowing for expansion in size of certain fruits, such as berries and cherries.

Collenchyma cells are long and narrow, contain protoplasm with thickened areas along sides and corners of the cells for strength. They are found in herbaceous stems and midribs of leaves where they provide valuable support for growth.

Sclerenchyma cells result from thickened and hardened parenchyma cells where protoplasm ceases and strengthening of the cell occurs. These cells appear in pears, and shells of nuts and are called fibers.



CROSS SECTION OF A TYPICAL CELL
FIGURE 9

Tissue and Cambium are the next stage of development. Tissue, the result of cell groups combining, called xylem and phloem, forms a system which connects the roots with leaves, flowers and fruits through the stem. The cells of xylem tissue conduct water and are called tracheids or vessels. Phloem tissues conduct the manufactured foods. This tissue consists of sieve tubes, dead fiber cells and living parenchyma cells. In woody stems of fruit trees, the xylem forms the wood, while the phloem makes up the bark or outside layers of the tree. Between the xylem and phloem is a layer of cells known as the cambium. Cambium cells constantly divide forming new xylem and phloem cells, and thus growth and expansion of the tree trunk occurs. The old xylem cells become the heartwood and pith inside the stem or trunk. The old phloem may die, become corky and fall off.

Annual rings occur in trees due to the mentioned cambium cell action and subsequent new growth. By counting these rings, the exact age of the tree can be established.

Meristematic Tissue is important because it is the tissue responsible for elongation of stems and roots. This type of tissue can be found at the apex (tip) of shoots and roots and because of its rapid division and subsequent development, both organs grow in length.

C. FUNCTION OF PLANT PARTS (ORGANS)

Roots are organs responsible for absorbing water and nutrients from the soil for growth and also lend physical support to plants and trees by their anchoring effect in the soil. The absorptive power of the roots take place through tiny cell structures, called roothairs, which are constantly growing and expanding in the soil.

Stems or Trunks provide a physical connection between the roots and leaves, therefore allowing for upward transportation of water, nutrients and manufactured foods for use in growth processes of leaves, flowers, and fruits.

Leaves are actually stems in themselves, although considerably modified. Their chief function is in the manufacturing of food whereby water and nutrients from the soil brought to the leaves through the roots are combined with carbon dioxide of the air.

Flowers are modified leaves on special type shoots. They are necessary in reproduction or forming seeds because they hold the male and female parts, either in the same flower (hermaphroditic) or in separate flowers (monoecious).

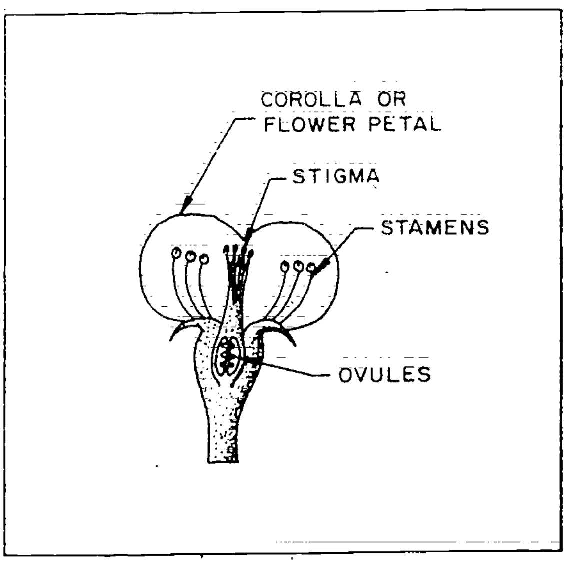
Fruits are not actually that important to plants or trees. Although seed(s) adhere to them, their importance lies mainly in economic value and not in serving a crucial function for growth.

Seeds function entirely for propagation purposes. In economic terms, they function as food for humans, such as wheat and corn.

D. REPRODUCTION AND FRUIT SET IN PLANTS

There are two ways which plants may be propagated. They are referred to as sexual (from seeds) and asexual (vegetative parts).

Sexual reproduction occurs from cell growth due to the male and female elements combining together. These two elements are produced in blossoms. The male portion is known as the stamen. It consists of a stalk or filament and the anther where pollen grains are produced. The female portion is called an ovulary. It contains a stalk or style and a stigma. In the ovulary are one or more ovules producing an egg cell which may or may not be fertilized by a male cell (gamete) from the pollen grains. Pollination occurs in two ways. Self-pollination occurs when pollen is transferred from the anther to the stigma in the same flower. Cross-pollination occurs when pollen from the anther of one flower is transferred to the stigma of another flower.



ANATOMY OF A FLOWER
FIGURE 10

Both types of pollination insure fertilization. Thus, the result is self-fertilization and cross-fertilization. The process of pollination and fertilization is greatly aided by various agencies. These may include wind, water, insects, and certain birds.

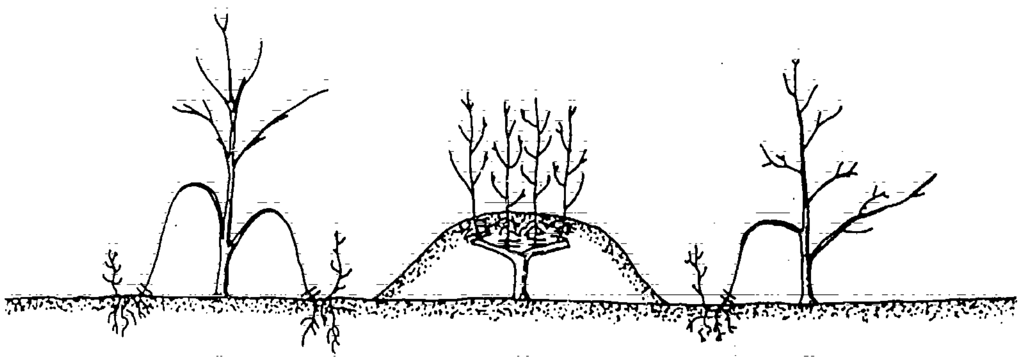
For example, wind may trigger the anthers to lose their pollen and thereby come into contact with the stigmas. Insects (honeybees) transfer pollen from one flower to another while in search of nectar by the means of pollen sticking to their legs.

Asexual reproduction occurs when certain vegetative parts of a plant are used to promote new growth of stems, leaves, or roots. Seeds are therefore not a part of asexual reproduction. With fruit trees, asexual reproduction is the most important means of propagation. Asexual reproduction takes place by various methods:

1. Cuttings - This includes both stem and root cuttings. Stem cuttings can be made on both herbaceous and woody materials. Common herbaceous plants propagated by stem cuttings are geraniums, chrysanthemums, and carnations. A stem (four inches long) with at least one growing tip is cut, placed in moist soil or sand and roots then begin to develop. Common woody plants, such as the rose and blueberry, can be propagated by this same method as long as the wood has matured. Many ornamental shrubs and trees are propagated by this method, including both evergreen and deciduous plants.

   Root cuttings are a common means of propagation for the blackberry and raspberry bush, and sweet potatoes. This method involves cutting a root about one-fourth inch in diameter and from two to four inches in length and planting in the same way as for stem cuttings. When planted, root development will take place.

2. Layering - This method refers to layers or branches of a plant or tree covered with soil. The branch part to be covered with soil is slightly broken forming an "elbow" and this is where probable root growth develops. This is because growth substances will accumulate at the broken point and promote rooting. After sufficient root development occurs, the branch with its root system is dug up and planted as a separate unit. There are three common types of layering used; tip, mound, and simple. (Figure 11.)



LAYERING
FIGURE 11

3. Grafting - This method refers to a type of asexual reproduction whereby a scion of one variety is united with a rootstock of another variety. Scion refers to a stem with one or more buds present, or a single bud itself. Rootstock, of course, is the lower portion of a plant or tree not containing buds. Whether buds or stems are used, the main requirement is to ensure that the cambium layers of both the scion and rootstock come into contact so that the cambium cells of each continue to grow and form a permanent bond between them. Also, it is well to remember that not all scions and rootstocks are compatible. Compatibility is learned by experience, but as a general rule plum, cherry, and peach unite with each other but not with apple or pear. In classification, they all belong to the same family but are of a different genus.

The grafting technique is the most important type of propagation in deciduous fruit orchards because of greater flexibility in uniting different scions to different rootstocks and relative ease of operation. There are several methods which can be chosen by the orchard grower to suit his individual needs.

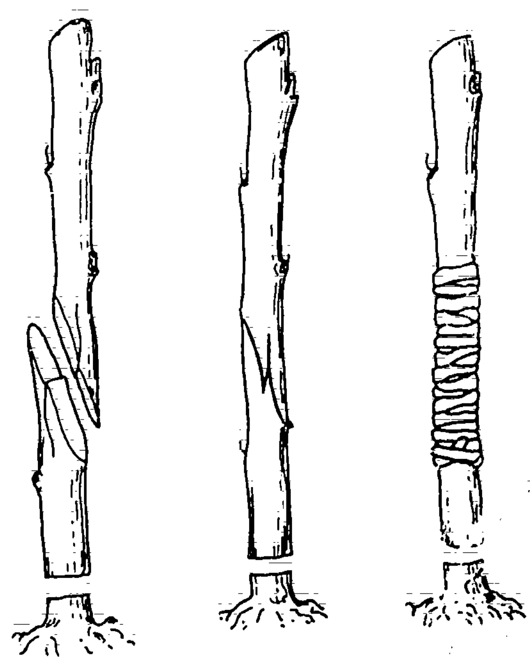
Grafting Methods

The Whip Graft (Figure 12) is used for propagation of apple or pear and certain ornamentals. This type of graft is common for (young) fruit trees where the diameter of the scion and rootstock do not exceed three-fourths inch. Both scion and stock are cut at slanting angles. About one-third of the distance from the pointed end of the cut on each piece, a tongue is cut. Both scion and rootstock are then locked together ensuring that both cambiums are in contact with one another. Then, a rubber band of desired length is wound around the graft rather tightly and uniformly. After banding, grafting wax or beeswax, in liquid form is painted over the entire grafted surface to keep air from entering the cuts and drying out the cambium.

Caution: Heated grafting wax should not be boiling but merely in a warm fluid state; otherwise injury to the delicate tissues may occur.

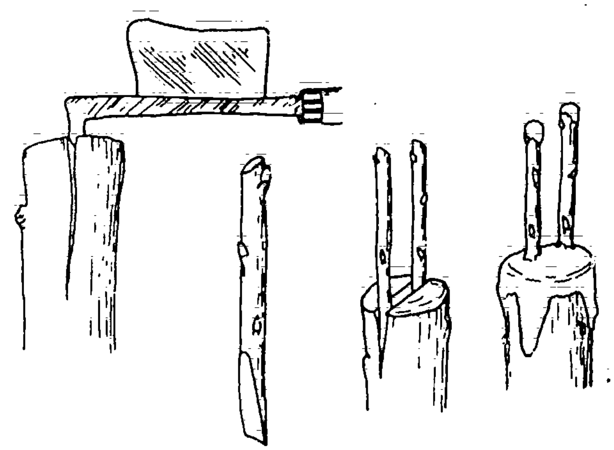
Formula of Grafting Wax

Resin	1 pound
Linseed Oil	3 fluid ounces
Parafin	5 pounds



WHIP GRAFT
FIGURE 12

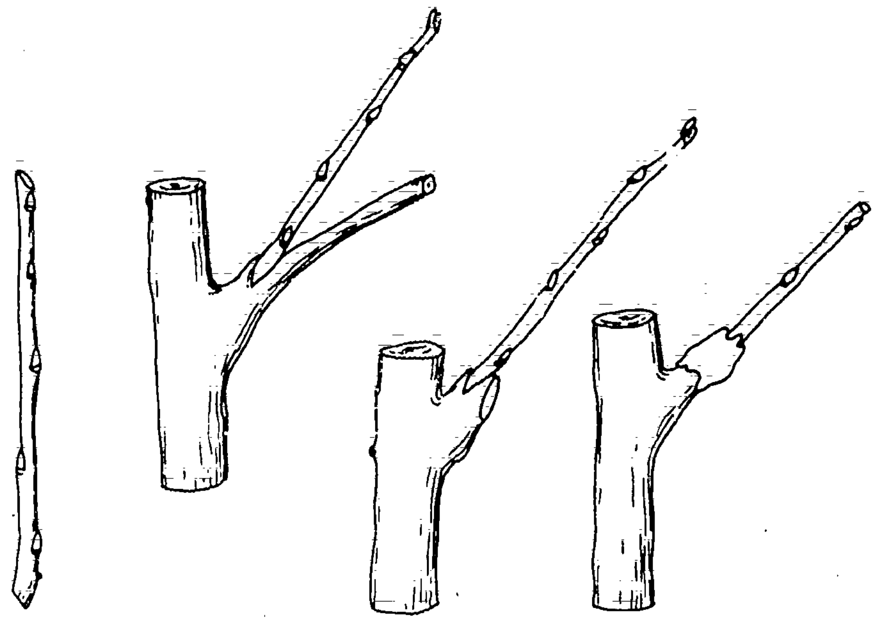
Cleft Graft is used on rootstocks with a diameter limitation ranging from three-fourths to two and one-half inches. (Figure 13) This method involves splitting the solid rootstock or stub and inserting two scions into the split. Both scions should have at least 50 percent contact with the outer cambium layers and each scion should be cut with two equal slants to fit the angle of the split. After inserting the scions, grafting wax is applied. Upon union, healing and growth takes place and the weaker of the two scions is cut and removed. This prevents a weak tree (poor angled crotch) from forming in the years to come. Always remember to check the grafting wax (at least once a week) to ensure that cracks have not developed which would require rewaxing.



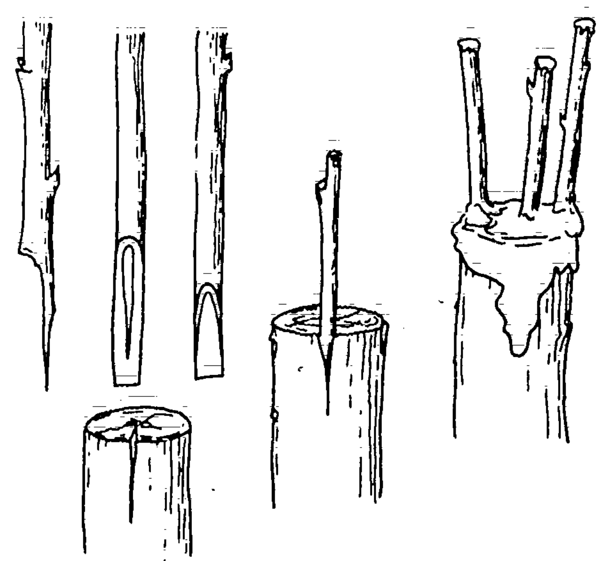
CLEFT GRAFT
FIGURE 13

Stub Graft. A new variety may be desired on an old, well-developed tree. For this, almost the entire top growth will need a replacement of scions. This replacement can be done with the use of stub grafts (Figure 14). Branches of one inch diameter can be used. An off-branch is completely removed and the desired scion is inserted about one to two inches from the main stem. Again, cambium contact and waxing are extremely important for success.

Bark Graft is sometimes referred to as inlay veneer graft. This method is useful on large stems or even trunks of trees. Many scions may be used with at least two buds present per scion. The procedural technique follows closely that of the cleft and stub graft -- except there is a slightly different cut of the scion (Figure 15). Because of the bark being older, the scion will usually be held quite firmly by the bark alone.



STUB GRAFT
FIGURE 14



BARK GRAFT
FIGURE 15

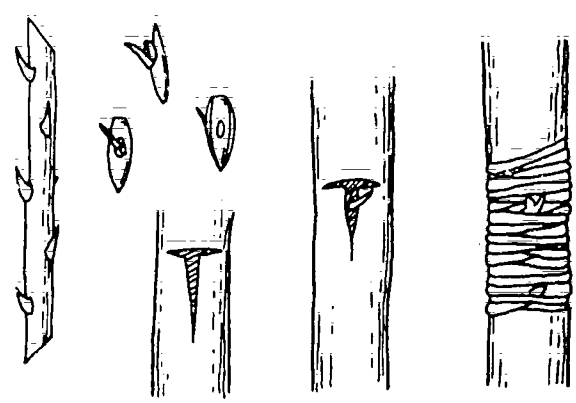
Budding. This method differs from other types of grafts in that only one bud is used and without its original scion. An existing bud is replaced by a new variety of bud. Success is again dependent on the union of the bud cambium with the cambium surrounding it by the branch or tree. Budding is increasingly being used as the main method of propagation over other grafting methods.

Bud wood selection: Bud wood is comparable to the scion in grafting. If budding is desired in the summer, the shoots of the current season's growth are used. The leaves are removed from the stem and only the middle half of the stem is used for budding (three to four buds). The remainder is discarded.

For spring budding, the wood is collected while still dormant. As for summer budding, spring cuts involve only the center bud portion of any one stem. This bud wood is then stored at 34° F to 45° F in moist burlap or gunny sacks.

Budding is done in several ways. One is called a "T" bud. (Figure 16.) A hortizontal cut is made in the stock and a vertical cut is made below it to form a "T". A bud is cut from desired scion variety in the form of a small shield, the woody tissue removed, and the bud inserted inside the "T". The cut area is then wrapped with a rubber band, twine, etc., and waxed. Actual budding is done in the spring just after terminal growth takes place and when the cambium is active, or in late summer while terminal growth is still active.

Other types of cuts are known as the "H" cut and the patch cut. The "H" cut is similar to the "T", except the "H" type has two vertical cuts, instead of one as with the "T". The patch cut is simply removing an entire patch of bark from a tree and replacing it with a bud of the same size.



BUDDING
FIGURE 16

UNIT III - INSECT AND DISEASE CONTROL IN ORCHARDS

A. CLASSIFICATION, DAMAGE, AND CONTROL OF INSECTS

Orchard insects may be classified three ways: (1) sucking insects; (2) chewing or leaf-eating insects; and (3) borers.

Sucking insects feed upon the foliage, bark or fruit of a tree by sucking juices from various tissues of the organs through means of a tiny beak. Damage, therefore, occurs according to the amount of liquid food consumed by such insects. Common sucking insects are aphids, scale insects, mealybugs, leafhoppers, and mites. All these insects are very tiny in size and are controlled by contact sprays (sprays which cause death of insects on contact because of burning, paralysis, etc.). Contact sprays such as nicotine sulfate, retenone and pyrethrum have been used for years in controlling sucking insects. Newer insecticides, such as DDT, chlordane, lindane, aldrin, malathion and dieldrin are more commonly used today as they are insecticides for both chewing and sucking insects. It is important to remember that any of these insecticides should be applied only when the insects are visible on the trees and applications should be made repeatedly (two or three times) to ensure that newly hatched larvae will be killed.

Chewing insects obtain their food by chewing and eating plant tissue such as leaves, flowers, buds, and fruit. Because such insects may consume several times their weight in food each day, the damage to fruit trees can be rather high and devastating. Common chewing insects include the apple-tent caterpillar, bagworm, brown-tail moth, cankerworm, webworm, cutworm, leaf roller, and Japanese beetle.

Since these insects chew plant tissue, control measures have always been effective by using a stomach poison such as arsenate of lead. However, DDT, chlordane, lindane, etc., are newer forms of insecticides and kill both by contact and through the stomach; therefore, they are more popular because of killing both chewing and sucking type insects with the same spray.

A few notes of caution are worth mentioning at this time. Any of the insecticides mentioned are usually sold under different trademarks in different parts of the world. Under any circumstances, it is well to spray according to the instructions marked on the package or bottle.

Also, any fruits that have been sprayed with arsenate of lead should always be washed thoroughly (possibly with a soap compound) before being eaten.

Borers are the most disastrous insects since they vitally affect the life of a tree by boring small tunnels between the bark and the wood, thereby destroying the cambium layer of the tree. They may also bore into sapwood and heartwood weakening the physical strength of the tree and allowing fungus to develop. There are many types of borers but they are usually classified as either flat-headed or round-headed.

Control of borers may occur through their predators or natural enemies, such as certain flies or the woodpecker which feeds on the larvae. More importantly, dead branches and dead trees should be removed and destroyed (burned) to eliminate future breeding places for these insects; but the most effective method again is one of chemical solutions or sprays. Two of the most effective materials are carbon disulphide and cyanogas applied directly into any visible tunnels of the tree where the borers may be present. After applying either of these materials, the opening of the tunnel should be closed with cement, mud, etc., to thoroughly fumigate the tunnel and kill the insects. A preventative control is to spray the tree trunk with DDT while the adult borers are laying the eggs. Another spraying should be applied as the young larvae hatch and move down the trunk.

The common peach tree borer, if allowed to penetrate below the soil surface, may be killed by applying paradichlorohenzene crystals around the trunk about two inches below the soil surface.

As mentioned, not all control is by chemical application. Biological control occurs when an insect's enemies keep it in check by feeding on it, thereby lowering its population in a given area. For example, the praying mantis feeds on live hornets, spiders, etc. Ladybugs or lady beetles feed on aphids or plant lice. In fact, if it were not for biological control, the world would be overrun by insects. Chemical control, by itself, would probably not be able to control such insect populations.

Some harmful insects may actually serve in a beneficial manner. Borers, for example, are useful when they are active in dead trees causing gradual decomposition of the tree. Termites can also be helpful in this capacity.

Some cultural practices may aid in the control insects such as pruning or thinning the fruit tree to allow easier and more complete spraying of an insecticide, painting tree trunks to reduce egg laying by certain borers, and using tarpaper collars around the tree base to guard against customers.

B. CLASSIFICATION, DAMAGE AND CONTROL OF DISEASES

Organisms responsible for diseases in fruit trees are grouped as bacteria, fungi, and viruses.

Bacteria multiply rapidly by cell division within the host plant. They are moved about from place to place in the spore stage by insects, man, animals, wind, and water. Certain bacteria are parasitic in nature deriving their food from living tissue. Other bacteria are saprophytic and thrive on dead tissue.

The most serious bacterial disease is known as fire blight. It strikes at the apple, pear, and quince fruit trees and is noticeable by the browning or darkening of flowers and leaves near the tips of twigs or branches, usually causing the branches to die. The infection occurs in early spring by bacteria which have been dormant during the winter season in infected twigs. It is usually spread by water and almost surely be bees during pollination. Pruning tools may also carry this bacteria as well as sucking insects. New succulent growth is most susceptible and complete loss of the tree may occur as well as an entire orchard.

Cultural control is effective in reducing the spread of this bacteria. Infected branches should be removed and burned. If this is done by pruning, the pruning equipment should be sterilized with a two to five percent solution of lysol or hexol. Fertilizer should be withheld to reduce the rapid growth of new succulent tissue. Any wounds should be sterilized with either lysol or hexol.

Chemical control includes spraying the blossoms with an antibiotic such as streptomysin.

Another serious bacterial disease is called crown gall. It infects mainly apple trees by entering wounds because of grafting or pruning and the result is swellings on the roots or in the trunk. Growth may be reduced and roots may die. Young trees are more susceptible than older ones. Prevention is the best control. Good cultural practices such as guarding against any wounds on the trees is a good step towards minimizing crown gall. If possible, always use resistant varieties or good non-infected nursery stock.

Fungi, like bacteria, do not manufacture their own food. They are, therefore, reliant on dead (saprophytic) and living (parasitic) tissues to sustain themselves. Fungi spores are transported in the same manner as bacteria. Fungi are complicated organisms probably best described as: multicelled with vegetative and reproductive stages. Certain fungi grow on the surface of a host plant causing powdery mildrews and shoe-string root rot; others may grow inside the host, erupt and cause downy mildews, leaf spots, blight, rusts, anthracnose, and scabs. There are others that remain entirely within the host tissue causing the plant to wilt and die or causing common "wilts". Thus, control measures are different for each type of fungi. Of particular importance to the fruit grower are the following types of fungus diseases and their possible control.

1. Anthracnose (blight) is a leaf and twig disease sometimes found in walnut, cherry, and plum trees. Symptoms are brown to reddish-brown or purple spots on leaves, particularly along and between veins. The leaves eventually die and fall off. Twigs become infected and the entire top growth of the tree may be retarded in growth. Death of the tree may occur. Control measures include burning of infected branches and twigs and spraying with three applications of Bordeaux mixture. The first spray is applied as buds break open, the second on young leaves, and the third on half-grown leaves.

2. Apple Scab and Cedar-Apple Rust are two diseases that are serious with apple trees and may cause loss from 50 to 100 percent of the fruit crop. Symptoms are raised circular lesions on the underside of leaves, fruits, and twigs. A certain type of rust actually requires two hosts to complete its life cycle. One is the Redcedar and the other is a species of the apple genus (Malus). If one of the two hosts is destroyed, the rust will not appear on the Malus type apple tree or Redcedar depending on which is being grown. Obviously, the apple tree is of concern here and, therefore, preventive control of this fungus disease would be to ensure that no Redcedars are being grown within at least one mile of the apple orchard. Chemical control includes periodic sprayings of either a sulfur or Bordeaux mixture starting with the leaf buds. Cultural control includes burning of diseased leaves, twigs, and fruits.

3. Leaf Spots appear as irregularly sloped areas, discolored, or dead tissue on leaves. This disease is sometimes referred to as blight or blotch. Leaf spots are not disastrous to a fruit tree except when the number increases without control and severe defoliation occurs. Spores are carried by the wind. Leaf spot is easy to control either by burning old leaves and/or spraying the new leaf buds with Bordeaux mixture. Sulfur sprays, dusts, and copper-lime dust can also be used.

4. Powdery Mildew forms a white covering over leaves. It, like leaf spot disease, is not extremely harmful and is easily controlled by burning of old leaves and spraying with wettable sulfur. As with leaf spot, the spores are spread by wind.

Viruses are infectious agents seen only through an electron microscope. They are known chiefly by what they do. They can neither be prevented nor controlled by spraying. However, it is known that plant viruses are transmitted mainly by sucking insects and since it is possible to control such insects, these viruses can be assumed to be controlled also. Control has also come about through breeding of resistant varieties of plants and trees.

There are two types of virus diseases classified as mosaics and yellows. Mosaics are defined as a mottled dark and light leaf color, and yellows as off color of a leaf. Both may result in stunted growth, crumbly fruit, and possible death of the tree. Peach, plum and cherry trees are highly susceptible to yellows.

UNIT IV - POME FRUITS

A. CLASSIFICATION AND DESCRIPTION

The botanist classifies the apple, pear, and quince as pome fruits. This classification is based on the premise of the botanical subfamily, Pomoideae, because of some common physiological characteristics. For example, all three of these fruits are, to some degree, susceptible to fire blight disease. Also, plants of this subfamily tend to be compatible for grafting on each other.

B. PLANT REQUIREMENTS

The apple is considered the most important pome fruit, having originated in Western Asia in the northwestern part of the Himalayas where, today, one still finds areas of wild apple species. An apple tree begins to bear after approximately six years of age and continues for another 40 to 50 years.

Climatic conditions favorable to good apple tree growth occur in the temperate zone, where the winter usually has freezing temperatures. Ideal soil conditions include a deep soil with good drainage and adequate water supply for the dry season, although apple trees are more tolerant of wet and poorly aerated soils (in comparison to many other fruit trees outside of the pome fruits). Tree spacings will vary from 35 to 50 feet, depending on the type of planting arrangement used. See Figure 17.

The second most important pome fruit is the pear. Since apples and pears are very similar in many respects, the information on apple trees can be applied to the pear tree. There are a few exceptions, however, and they are as follows:

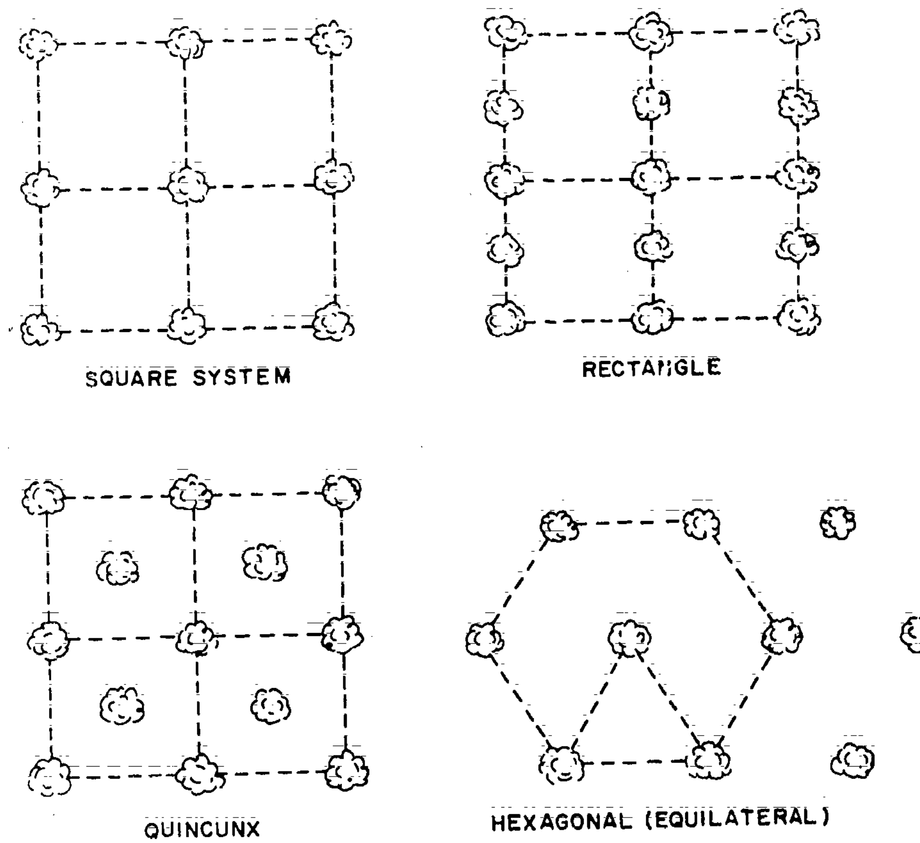
1. In general, pear trees cannot tolerate extremely cold winters or hot summers as well as the apple tree.

2. Pear tree growth is more upright than that of most apple trees and, as a result, plant spacings can be reduced to 20 to 25 feet.

3. Fertilizer applications become a sensitive factor with pears due to the fact that fruit bearing occurs almost entirely after vegetative growth slows down. Thus, lighter applications of fertilizer may be desired as well as lighter pruning.

4. Pears bloom somewhat earlier than apples and are more susceptible to fruit injury in a late spring.

The quince ranks third among pome fruits. It is grown as an ornamental and for the preserves and jellies processed from its fruit. The quince tree is very susceptible to fire blight and quince rust.



TREE—PLANTING ARRANGEMENTS
FIGURE 17

C. PROPAGATION

Apple trees are mainly propagated asexually by budding. Varieties of suitable local apple rootstock are used and desirable buds (two or three), or the scion, are grafted to one another.

As with apples, pear trees are also propagated by the budding method. Besides using pear seedlings as rootstock, quince rootstock can be used if dwarfing is desired.

The quince is propagated usually on its own rootstock attained from cuttings or layers.

D. PRUNING

Pruning of fruit trees may be defined as the art of cutting away parts (branches, twigs, etc.) of a tree for the purpose of actually training branch growth in such a way as to reduce limb breakage due to heavy fruit loads and also to facilitate spraying, thinning and harvesting of fruit. In general, best pruning results are attained when pruning takes place either in late fall or early spring after leaf fall and before leaf set. Pruning reduces total volume of growth, but it also increases the nitrogen supply to the remaining buds of a tree. Heavy pruning, as such, will then promote heavy vegetative growth, which may not be desirable for certain fruit trees as this may delay fruit-bud formation and further reduce the total crop.

Pruning is very important during the early years of a fruit tree as these are the so-called "formative" years for establishing a good and strong framework for heavy fruit bearing. By pruning, a fruit tree can actually be trained to grow in such a way to produce this strong framework. Fruit trees, by their natural process of growth, simply do not prepare themselves for heavy fruit bearing, therefore, artificial methods are required.

In pruning the young pome fruit trees, a system known as the "modified leader system" is widely used. This system involves the selection of three to five main branches around the trunk, spaced approximately one foot apart and at a wide angle with the trunk. Each selected main branch should have two to three well spaced side branches which serve to form the basic structure of the tree. This type of system will usually take two to three years of growth to develop.

As the tree gets older, broken and diseased branches should be removed. Any suckers or "water sprouts" should also be removed. If many inside branches are developing, these should be thinned out by good pruning.

Pruning itself is done with a sharp handsaw, hand shears, or actual pruning tools available in most parts of the world. Pruning cuts should always be made as close as possible to the branch origin. Usually the bottom of the branch is cut first and then the top. This will help prevent tearing the bark due to the weight of the branch. Since fire blight is a serious disease in pome fruits, pruning tools should continually be sterilized in either lysol or hexol.

UNIT V - STONE FRUITS

A. CLASSIFICATION AND DESCRIPTION

Peaches, plums, cherries, apricots, almonds, and olives are all considered stone fruits. With the exception of olives, all are deciduous trees; that is, they shed their leaves during the winter or dormant season. The olive, on the other hand, is considered an evergreen fruit because it does not shed its leaves during the dormant season and there is actually a certain amount of growth that takes place the year round. Olives and other evergreen fruits are considered to be subtropical or tropical plants and highly intolerant of low temperatures.

Stone fruits are also known as drupe fruits. In botanical classification, stone fruits belong to the Genus Prunus. All of the stone fruits have a hard and strong inner endocarp or seed.

As in all classifications, the stone fruits have certain physiological characteristics common to all of them. Fruits, flowers and young shoots of this genus are nearly all susceptible to a brown-rot fungus. Many viruses attack the stone fruits. There is some degree of grafting compatibility, although the degree is not as great as that among pome fruits.

B. PLANT REQUIREMENTS

Peaches are one of the most important stone fruits in the world, having originated in Persia. It is a rather large fruit and quite tasty.

Peach trees grow well in relatively light soils (pH of 6.0) which are even sandy in texture. Water and nitrogen requirements are quite high. A climate, which is generally frost-free, is best for peaches because they tend to bloom early in spring and are not particularly tolerant of cold winters.

Spacing requirements vary according to soil and type of pruning but, in general, 15 to 20 feet is desirable. Spring planting of young nursery stock is desirable to avoid winter injury. The young peach tree is set slightly deeper in the orchard than from the nursery. The roots should be well packed with soil at planting time.

Plums are another important stone fruit. They are native to many places and particularly to parts of the United States. They grow on a wide range of soils and are quite tolerant of wet and poorly aerated soils.

The greatest climatic limitation relates to the brown-rot fungus. A climate where summers are cool and dry will greatly aid in reducing the incidence of this fungus.

A spacing of 20 to 25 feet is often common in plum orchards. Young trees are planted in the spring although they are much more tolerant of cold winter than is the peach tree.

Certain types of plums are used for prune making. This is possible if the plum has a high sugar content and a firm flesh. The process of making prunes is rather simple. Desirable plums are immersed in a solution of one pound of lye per 20 gallons of water for a few seconds. This allows for the wax of the plum to be removed. The plums are then perforated by running them over a board of needles. This allows the skin to be permeable to water. The plums are then placed in the sun or dehydrators and allowed to dry.

Cherries are known as either sweet or sour (pie cherry). Usually sour cherries are canned or frozen while the sweet cherry is sold as a fresh fruit.

"Sweet cherries" originated from the area between the Black and Caspian Seas. Climate is the most important factor for sweet cherry growth. Since it is susceptible to brown-rot, it is best grown in areas where the summers are cool and dry and winters rather mild. Sweet cherries do suffer from cold winters. Soil conditions favorable to sweet cherry growth are found on deep, well drained soils. Sweet cherry trees grow well in low rainfall areas because of early fruit ripening before depletion of soil moisture occurs. Orchard spacing is usually within the range of 25 to 35 feet and cover crops are usually planted for cultivation purposes. Sweet cherries require less nitrogen than do peaches.

"Sour cherries" originated from the same area as the sweet cherry. In contrast to the sweet cherry, the sour type requires more nitrogen for growth and fruiting and also more water. Climatically, sour cherry trees thrive better in colder climates versus the warmer areas for the sweet cherry. This is because the sour cherry tree requires a rather long chilling time during winter for its growth processes. However, severe cold winters can also cause damage to the sour cherry tree. Young trees are planted in the spring with a spacing of 20 to 25 feet. Cover crops are also used in sour cherry orchards.

Apricots are an important stone fruit originating in Western China but are restricted climatically for good fruit set. This is because apricot trees bloom earlier than the peach, and frost-free areas are that much more important. It is also limited to areas where summers are relatively dry, thus reducing the danger of brown-rot. Nutrient requirements, particularly nitrogen, match that of the plum but are not as great as the peach.

Almonds are generally referred to as nuts, but are really stone fruits originating in Western Asia. The big difference between the almond and other stone fruits is that it is the seed of the almond which is eaten and not the fleshy fruit as with peaches, plums, etc.

As with apricots, the almond tree is especially susceptible to an early frost because of early bloom. It is therefore essential to grow almonds in frost-free areas. Almonds do exceptionally well in heavy soils. It also competes with the peach tree for a high requirement of nitrogen.

Except for one or two species, the olive tree is a tropical plant, as previously mentioned, and thrives mostly on poorly aerated soils of the world. However, this is not the ideal soil for olives as a good, deep well-aerated soil would produce better olive crops. Olives require less water than most orchard trees, due mainly to lower transpiration losses. However, its nitrogen requirements are as high as most deciduous fruit trees. The olive tree is thought to have originated near areas of the Mediterranean. Today, Spain produces the largest share of the world's olive crop.

As for climate, the olive tree will tolerate lower temperatures than other evergreen orchard species. A mild chilling season is desired to induce flowering. The most dangerous disease of olives is called olive knot. This bacteria enters bark wounds and produces warty growths, sometimes causing death of the tree. Control is by cutting out the growths and disinfecting the wounds and pruning tools. Spacing of trees in an olive orchard usually is about 35 feet.

C. PROPAGATION

Peaches - Peach seedlings used as rootstocks and scions of suitable varieties are budded on to the rootstock. Trees are budded in late summer and after one year's growth they are sold as nursery stock.

Plums - Propagated in the same manner as peaches using suitable plum rootstock.

Cherries - Also budded on various cherry rootstocks in a similar manner to peaches. This is true for both the sweet and sour cherry.

Apricots - Budded on either peach or apricot seedling rootstocks.

Almonds - Grafted onto their own rootstocks.

Olives - Can be propagated by cuttings. This is done using older leafy shoots cut about four to five inches long with at least two leaves at the top of the shoot. The cutting is then placed in moist sandy soil where root development occurs. Cuttings should be made in the fall. After two summers in a nursery, the individual cuttings should be ready for transplanting to the orchard.

D. PRUNING

Peaches - The young tree should be pruned leaving two to three side branches about two to three inches long. The main stem should be cut at a height of 24 to 30 inches. During the second year, the main scaffolds will have developed and secondary branches will occur. Pruning at this stage includes thinning out competing branches. Since fruit bearing occurs on new growth each year, continual pruning or heading back of old wood should be done for each successive year.

Plums - Since there are so many varieties of plums with varying growth habits, it is difficult to recommend a specific system of pruning. However, the modified leader system with apple trees would probably serve most orchard needs.

Cherries - Of all orchard species, both the sweet and sour cherry tree require the least of pruning as the tree matures. However, at one year of age, it is advisable to train the growth with the modified leader system. Very light pruning of cross branches or rubbing of branches is all that is required in later years of growth.

Apricots - The modified leader system is used in most apricot orchards.

Olives - When planted in the orchard, young olive trees (bare-root) are cut back to a height of 24 to 30 inches. There is very light pruning throughout the life of an olive tree. Only water sprout removal and general shaping of the tree is required. Heavy pruning is not desirable as serious setbacks in fruiting will occur.

Almonds - As with most orchard trees, the modified leader system is recommended.

UNIT VI - NUTS

A. CLASSIFICATION AND DESCRIPTION

For purposes of this manual, only the pecan and walnut are discussed, although other nuts such as the pistachio, hazelnut, and chestnut are important as well. Because of its close relationship to stone fruits, almonds are not discussed in this section of the manual.

Edible-nut trees are of economic importance because of human consumption of the mature seeds, similar to almond, which they produce. Again, as with almonds, the seed is what is eaten and not the fleshy part covering the seed.

In classification, the walnut and pecan belong to the family Juglandaceae.

B. PLANT REQUIREMENTS

The walnut tree originated in many parts of the world, most notably China, Japan, India, United States, and South America.

It is one of the few deciduous orchard trees that is very sensitive to shallow and poorly aerated soils. This is due to the fact that its root system must be able to permeate soil to at least a depth of five feet. Because of the deep root system, cover crops are very important, allowing for better water penetration through the soil.

Climatic limitations vary greatly because of so many walnut varieties. In general, conditions favorable for almond orchards will suite the walnut tree as well. A light chilling winter is desirable for most varieties of walnuts. This is true for example in the State of California (U. S. A.) where warm winters occur in the southern portion of the state and colder winters in the northern part where most walnut orchards are found today. In fact, California supplies most of the walnut crop for the entire United States.

The pecan is native to the United States and much of the annual crop is still harvested from wild trees in various parts of the country. It can be grown in both humid and arid climates. However, since most pecan growth takes place in the wild, best crop growth and yield have been found in soils that are very deep and well-drained. In arid areas, pecan orchards are sometimes placed along the rich and fertile soil of streams and rivers. This allows for available water by seepage to sustain growth during the dry periods. However, because of higher susceptibility of various diseases in humid areas, it may well be undesirable to invest in a pecan orchard.

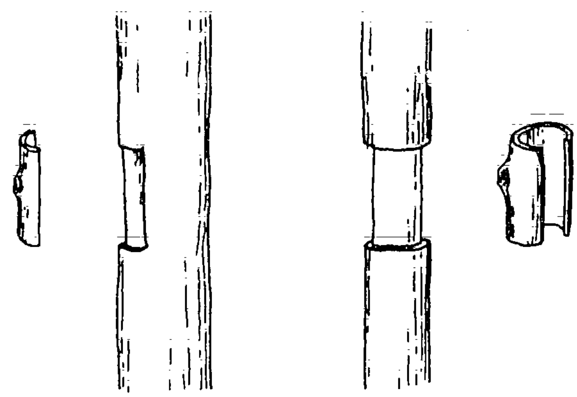
Spacings vary greatly and should be determined more by local varieties used and their ultimate size at maturity. This is also true for the walnut tree.

C. PROPAGATION

Walnut - Usually its own seedling rootstocks are used and desired scion buds are grafted onto these rootstocks. However, in many parts of the world, propagation takes place only by seedlings and no grafting occurs.

Pecan - Follows much the same pattern of propagation as with the walnut.

For both walnuts and pecans, better yields can certainly be brought about by grafting different varieties to different rootstocks. As stated, this is done by budding and specifically with the patch or ring bud (Figure 18).



PATCH OR RING BUD
FIGURE 18

D. PRUNING

For walnuts, very little research has been conducted on good pruning practices. It is recommended, however, that the fast growing and succulent water sprouts be removed if they arise due to abnormally warm winter weather.

Generally, there are no specific rules for pruning the walnut tree. Experience with local varieties by trial and error is the best method.

Pecan trees require very little pruning as they are natural and, therefore, rare in building a strong framework. This obviously is a great asset for the orchardman.

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UNIT VII - CITRUS FRUITS

A. CLASSIFICATION AND DESCRIPTION

As stated before, evergreen fruits include the citrus group which grows on subtropical or tropical plants. These fruits are quite sensitive to low freezing temperatures. The evergreen citrus tree does not require the long rest period during winter as is so often necessary for deciduous types; it usually maintains at least a minimum level of growth throughout the year.

Common citrus fruits considered in this manual are the orange, lemon, lime, and grapefruit. All are botanically placed in the family Rutaceae. Citrus fruits are native to the Old World -- in China, India, Philippines, Australia, and Africa. Now they are grown in almost all tropical and subtropical areas of the world, including South America and the southern United States where temperatures are cooler than their original native habitat. Most citrus fruits are acid in taste, except for the sweet orange. Those that are too acidic for eating are usually consumed in a form of drink or in cooking.

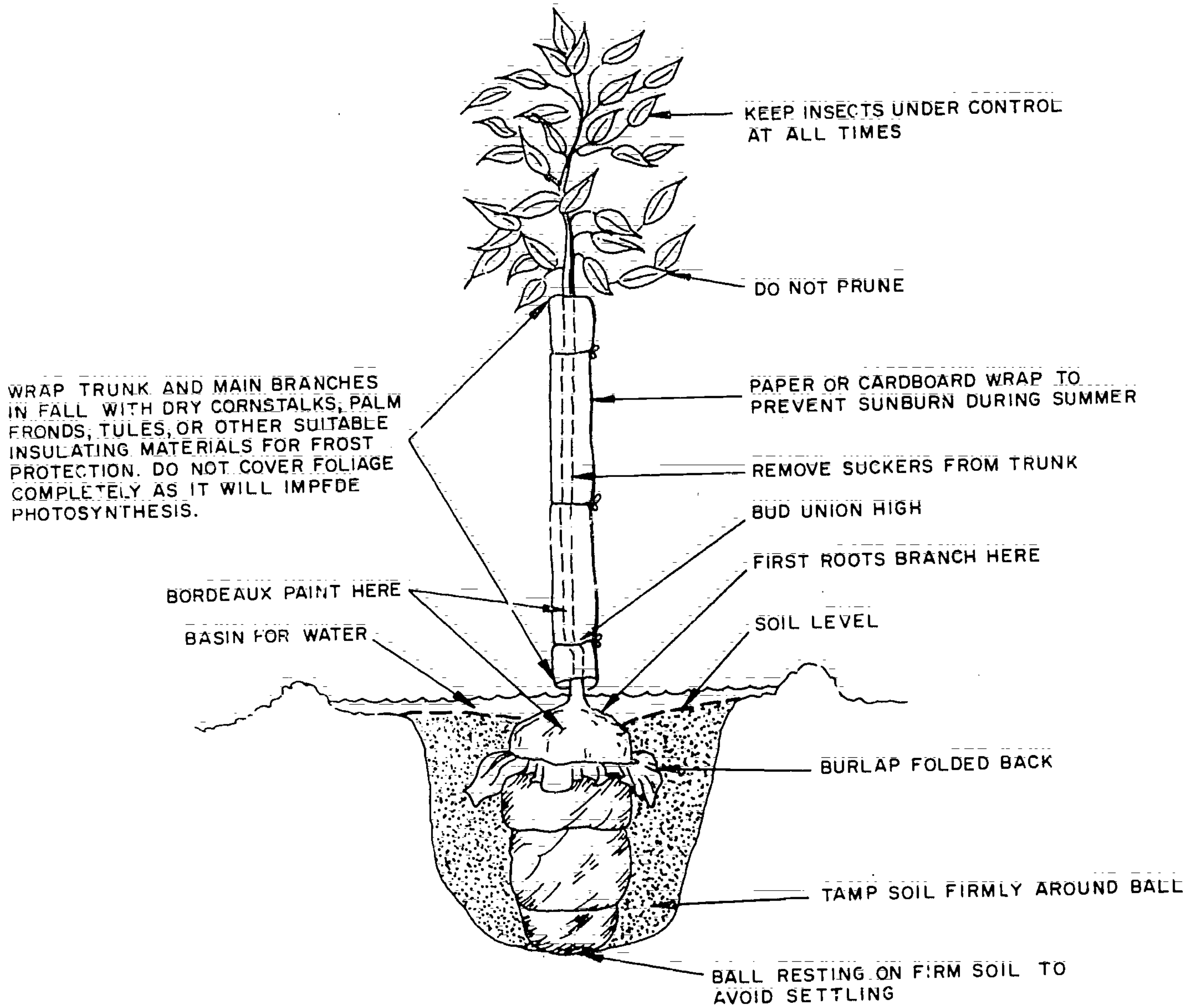
Some people often confuse lemons and limes as they quite often appear to look and taste alike. Botanically they are very similar; however, the most distinguishing factor between them lies in their climatic requirements for growth.

Limes grow best in warm and humid regions and are most prominent in the tropics. Lemons require cool and dry environments and are most likely to be found in subtropical areas. A person is, therefore, more likely to find a lemon on the market in San Francisco and a lime in Manila.

Oranges are either of the sweet or sour type. Both types are similar in size, growth, and appearance. The sweet orange is favored for eating purposes while the sour orange is used chiefly as rootstock for propagation of the sweet orange, grapefruit, and lemon. Its rootstock is highly resistant to several trunk diseases.

B. PLANT REQUIREMENTS

Citrus trees grow on almost any type of soil. Their root system is not a deep one and tends to spread out near the surface of the soil. Because of this, citrus thrives best on well-drained sandy loam, loam, and clay loam soils. Soil structure with a good supply of nutrients is important. If



PLANTING A YOUNG CITRUS TREE FROM NURSERY STOCK

FIGURE 19

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soil moisture is not readily available, irrigation will be required. In the Far East, citrus trees are often planted near or along river banks, streams, etc., to allow for a good supply of moisture as well as adequate drainage.

Oranges are grown in both subtropical areas and higher elevations of tropical countries where monsoon rains occur. Grapefruit trees do well in tropical lowlands.

These are wide variations of spacings in a young orchard ranging from 15 to 35 feet, depending upon varieties being grown. If moisture is not a problem, a cover crop is usually grown in a citrus orchard.

Planting Instructions for Citrus

Select the proper tree from well-grown nursery stock. The foliage should be large, have a uniform healthy color, and be free from evidence of pest damage and nutrient deficiencies.

A one year tree should have foliage the full length of the trunk and the bark should be bright and clean. The bud union should be well-healed and free from evidence of sunburn, mechanical injury, or poor stubbing of the rootstock.

The bud union should be at least six inches above the ball. The trunk should be straight and show uninterrupted growth as evidenced by the growth nodes on the trunk.

The ball should be moist but not wet, and the soil should be a solid cylinder. The ball should be securely tied with a good quality of burlap. No root stubs should protrude from the ball.

It is important that buds come from trees which are true to the variety desired, and are known to be productive and free from disease.

The proper selection of nursery trees can largely govern your success in the production of quality citrus fruit.

C. PROPAGATION

The four citrus fruits are quite interchangeable for propagation purposes. In general, citrus trees are propagated asexually by budding on seedling stocks. The citrus fruits mentioned below are desirable, usually, from the standpoint of their adaptability to varying soil conditions.

Sour Orange - Desirable rootstock for other citrus trees because of promoting good tree growth and fruit quality on heavy soils with poor drainage.

Sweet Orange - Good for rootstock use on rich sandy loams.

Lemon - Suitable rootstock on light sandy soils where shallow soils lie on rich formations.

Lime - Not a desirable rootstock but when used, it is used only on light soils.

Grapefruit - Adaptable to rich loamy soils but not at all desirable on light sandy soils, therefore, it is not widely used as a rootstock.

D. PRUNING

Pruning of citrus trees is not as important as with deciduous fruit trees. After the main scaffold branches have been developed, very little pruning is required throughout the life of the tree. Pruning of young trees centers mainly around the removal of water sprouts and training of the scaffolds. With bearing citrus, removal of dead wood is about all that is required.

UNIT VIII - VINE FRUITS

A. CLASSIFICATION AND DESCRIPTION

For purposes of this manual, only the grape is discussed because of its importance in many parts of the world, particularly in developing countries. Grapes are an important vine crop because they can be used for wine making, raisins, and for table purposes. Grapes are thought to have originated in Asia Minor and more specifically in Northern Iran. While there are many species of grapes, the Vitis Vinifera is probably the most important as it has dominated the European grape industry for years. It is sometimes referred to as the Old World grape.

Grapes grow actually as vines and live almost indefinitely. Fruit is borne on the previous year's growth known as canes. Current season growth is called a shoot. Thus, the shoot becomes a cane the following season, and so on. Often, in approximately three years, it forms the trunk or branch of the vine.

B. PLANT REQUIREMENTS

Well-drained deep soils are the best for grape culture. Since a late spring frost can be damaging to the blossoms, freedom from frost and cold winters is quite important. Areas or elevations which provide for good and quick drying of foliage after rains are important to reduce the danger of mildew. With commercial production of grapes being trained to grow on overhead wires, no cover crops are used in the vineyard and clean cultivation is maintained. Because of this, a vineyard should be selected where soil erosion will not be a problem or can at least be controlled.

C. PROPAGATION

Grapes are propagated by grafting, cuttings, and layering, depending upon the variety involved. With layering, a strong one year cane is placed in a trench three to four inches deep and the end is left protruding. The cane is then covered with soil and rooted vines may be produced in one season.

Cuttings involve using a cane which includes three buds. One cut is made close to the bottom bud and the second cut is made one inch above the top bud. When placed in the field, only the top bud should remain above the soil surface and the canes should be spaced three to four inches apart in rows. As with layering, cuttings will root and young plants will be ready for field planting in approximately one year.

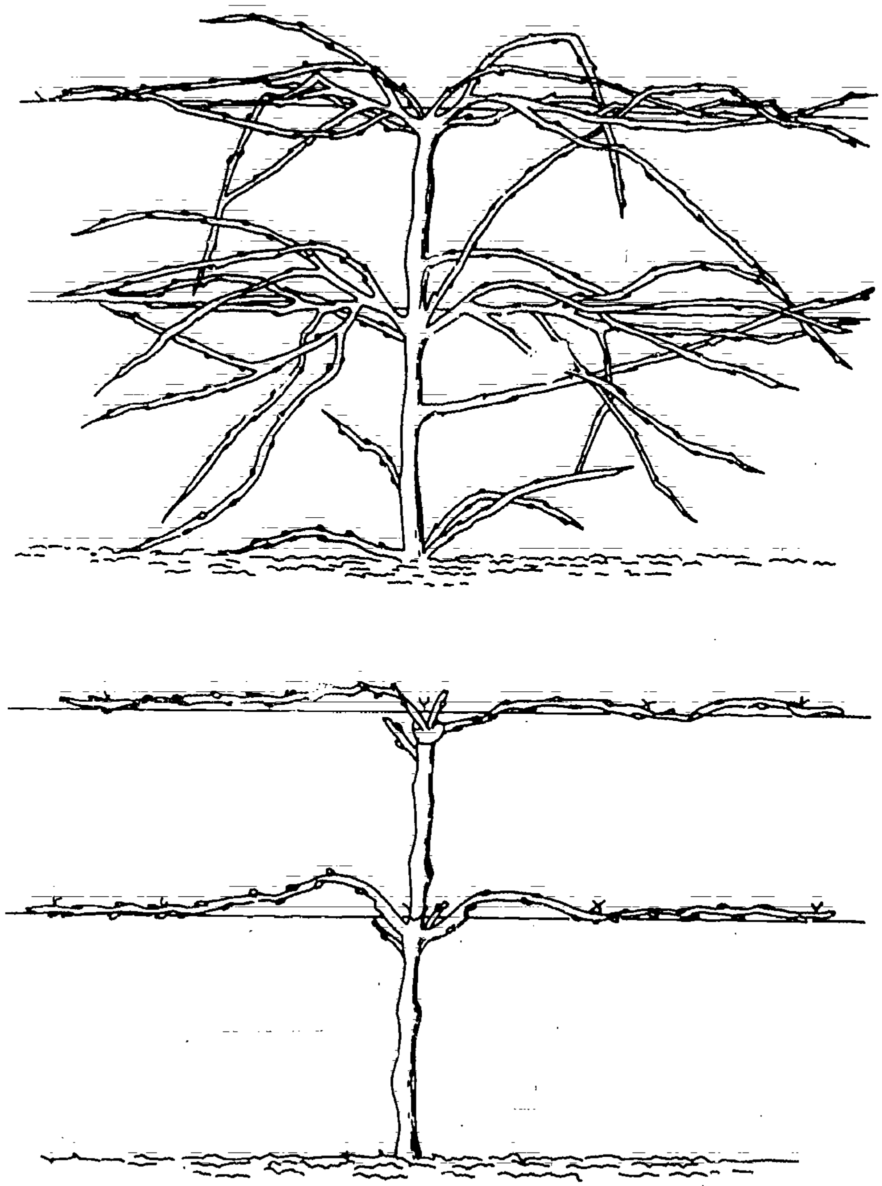
D. PRUNING

For grapes, pruning, and threfore training, of growth depends entire on the species grown. Some species are trained on wires, others on stakes, and wild grapes take their own course. To achieve commercial grape produc tion profitably, some system of pruning and training is necessary. This is due to the fact that a vine fruit, in this case grapes, does not form a strong scaffold system and does not necessarily grow in a uniform upright position thus allowing for inefficient irrigation, weeding, and harvesting. By "trainii grape vines to grow on wires, poles, etc., these problems are overcome anc better yields occur.

One popular training system is known as the "Kniffin System". See Figure 20. It is thought worthy of detailed discussion in this section becaus of its adaptability to many parts of the world.

The development of this system may take three years. It involves th construction of two lines of wire approximately two feet apart and supported by posts placed in a single row of desired length. When a vine is planted, it is cut back to two buds. After the first season, the stronger shoot is select and tied loosely onto the top wire. The second shoot is removed entirely. When the third season begins, two or four of the best shoots from the origin shoot are chosen and tied horizontally to the wires to allow for fruiting. Al other growth is removed. Fruiting canes, about the size of a pencil, are cu back to five to eight buds each.

Once this framework is developed, pruning is done only to reduce th number of buds to ensure new shoot growth and fruiting for the next season' growth and harvest.



KNIFFIN SYSTEM
FIGURE 20

UNIT IX - TROPICAL FRUITS

A. CLASSIFICATION AND DESCRIPTION

Three important tropical evergreen fruits are the banana, papaya, and mango. Of these, the banana and mango seem to have orginated in India, where both are still grown widely today on millions of acres of land. The papaya, on the other hand, is native to tropical America, particularly Mexico and Central America. Botanical classification differs for all three. The mango belongs to the family Anacardiaceal, the papaya Caricaceal, and the banana to the family Musaceal.

The banana is a common table fruit, very rich and high in food energy. It is favored for human consumption because of its ease for eating simply by peeling away the outer skin of the fruit.

The papaya is a rather large fruit, oblong in shape and greenish-light yellow in color, containing small black seeds. Its food value is low and, in addition to serving as a fresh fruit, it is now grown widely as a source of papain. Papain is an important enzyme material used in tenderizing tough meats. (Figure 21.)

Mangoes are somewhat similar in shape but smaller in size to papayas. When ripe, the mango is orange colored with mixtures of purple and red. The flesh of the fruit is yellow to orange in color and quite juicy. Its economic importance lies mainly in local consumption in the lowland tropics where millions of people enhance their diet considerably because of the relatively good vitamin supply it contains. (Figure 22.)

B. PLANT REQUIREMENTS

Bananas do best on loam soils that are well-drained and aerated to at least six feet in depth. Banana trees require a tropical climate and will tolerate cool temperatures in such areas barring frost. However, ideal banana plantations occur best where the temperature ranges from 60°F to 95°F. The optimum condition for growing bananas is about 75°F for most of the year. With such an ideal climate, it is likely that the annual rainfal will be quite adequate for good growth and maintenance. If conditions are not ideal, bananas require irrigation as they are more sensitive to water deficit than most other orchard species, excluding the papaya. Spacings of ten feet apart are used on many plantations.

PAPAYA
FIGURE 21

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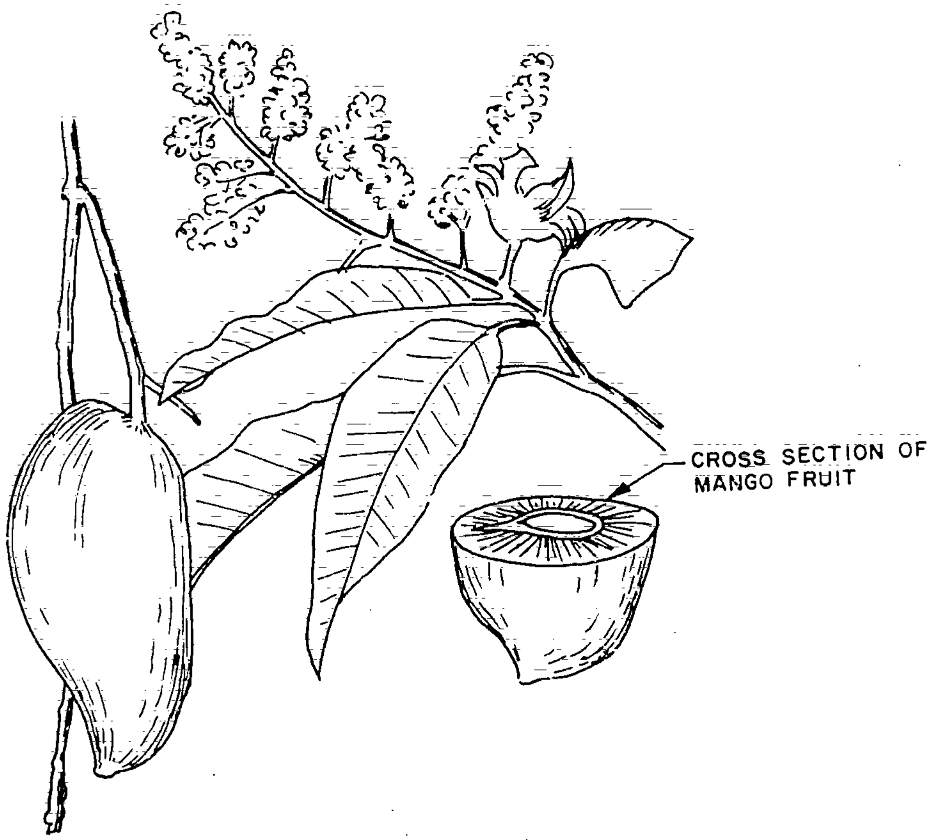


MANGO
FIGURE 22

Papaya trees tolerate many kinds of soil provided they are well-drained to a depth suitable for the root system to develop and that the devastating root knot nematodes are not present, or at least no history of it in the area.

As papaya is also a tropical plant, it thrives best in those areas suitable for bananas, although the papaya will tolerate cooler weather than some other tropical plants. However, the cool weather is not ideal as it retards growth and causes bad flavor in the fruit.

It is important to remember that the papaya tree is affected more by water deficit, in terms of yield, than most other orchard species. Therefore, it is of utmost importance to ensure adequate soil moisture at all times. Papayas may be planted from 10 to 12 feet apart.

Mango trees will not tolerate poor, shallow and impervious soils. They will not necessarily die but yields will be severely reduced. Since the mango is very tender to cold temperatures, it too is limited to growth only in tropical or near tropical climates. Water deficits seem not to be as severe with the mango tree in comparison to the banana and papaya. Spacings vary from 25 to 50 feet depending on varieties used.

C. PROPAGATION

Banana - Propagated most commonly from rhizomes (the stemy part of the plant underground) cut from old stools or stumps. The rhizome pieces are prepared by trimming away any roots and dipping them in a five percent solution of formaldehyde. It is important to remember that the rhizome must contain at least one bud. The rhizomes are set twelve inches in the soil in eighteen inch wide holes.

Papaya - Usually propagated by seedlings. Mature papaya seeds are planted in pots and tin cans (about three or four seeds per container). After three to four weeks when germination has occurred and three or four leaves develop, they are then transplanted to the field. When planted in the field, it is well to remember that the roots should be carefully handled so as not to cause injury and the individual seedling should be shaded from the sun. The papaya tree will fruit for a maximum of eight to ten years. In practice, replanting occurs about every four years.

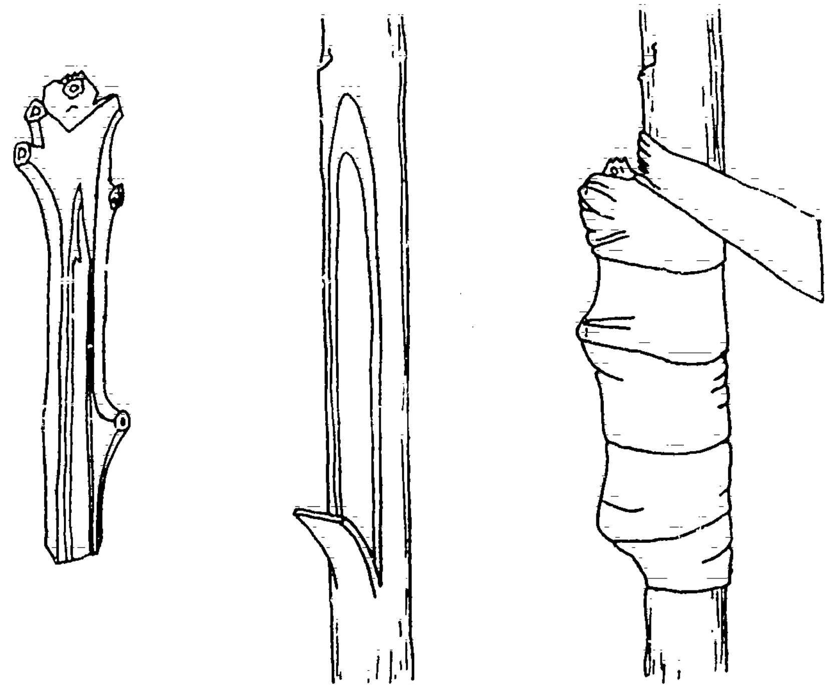
Mango - Some varieties are propagated from seed, but most are vegetatively produced by grafting on their own seedling rootstocks. The particular type of grafting commonly used is called veneer grafting. (Figure 23.)

D. PRUNING

Banana - Removing and regulating of fruit sucker growth is usually all the pruning required. This is done to avoid too many suckers competing for nutrients and water and therefore lowering yields. Also, suckers from the base of the tree, or from the rhizome area, are removed as wind may damage a heavy growth or "bunch" of bananas growing at that location on the tree.

Papaya - No pruning required as young trees grow and fruit on a single stem. After a few years (two to three), they become less productive, fruit is smaller, and usually the orchard or plantation is replaced with new stock.

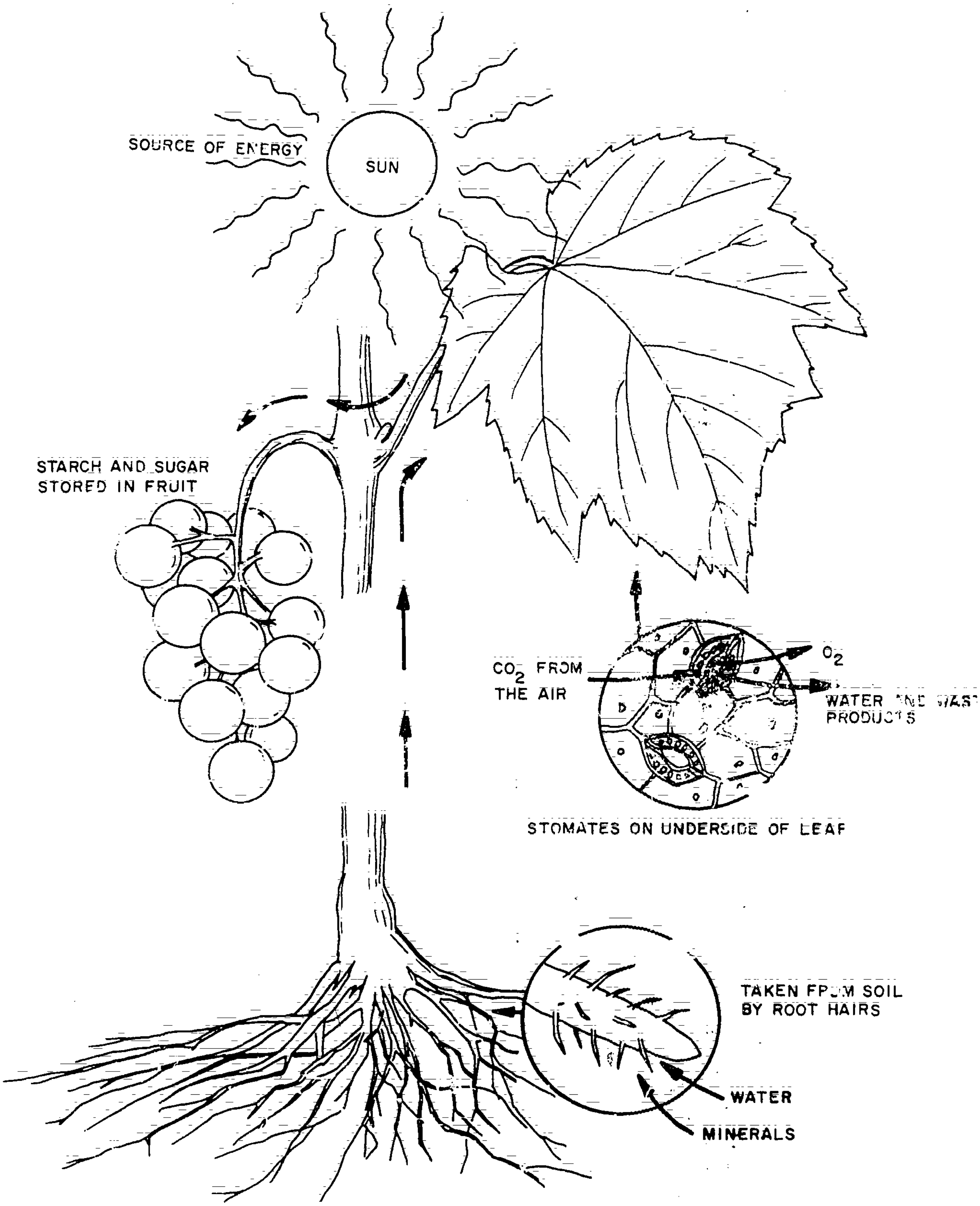
Mango - Very little pruning required except when the tree is young. Pruning may be required to remove crowded branches and hard to reach thin branches in top of tree for purposes of lowering total branch growth of the tree.



VENEER GRAFTING OF MANGO
FIGURE 23

APPENDIX

PRACTICAL EXERCISES



PHOTOSYNTHESIS
FIGURE 24

PHOTOSYNTHESIS

I. Title

Green Leaves and Food Synthesis

II. Introduction

Photosynthesis is the most important chemical reaction in nature. It supplies the basic needs for all life, both plants and animals.

A. Have you ever wondered why leaves are green?

B. Is there something about the green color that is important to plants?

C. What do we call the green substance?

D. From where does the green substance come?

E. How important to the plant, or to us, is this green substance?

F. How important is light to this overall process?

G. What are the raw materials for photosynthesis?

H. What are the products?

III. Conclusion

Many processes occur in the leaf, but one of the most important is that of food manufacture. Green plants possess the ability to manufacture food from raw materials derived from the soil and the air, and upon this activity depends not only the life of plants but also the life of all animals, including man. Photosynthesis is the manufacture of sugar from two simple raw materials -- carbon dioxide and water -- in the presence of chlorophyll (the green coloring matter in plants) and with sunlight as the source of energy. Oxygen is a by-product. Since light is necessary, the name photosynthesis (photo - light; synthesis - a putting together) is appropriate.

V. Questions

A. Of what importance is photosynthesis to the potato or turnip plant?

B. Could we live without the aid of green plants? Why?

C. Why is the lack of chlorophyll in some ornamental plants a desirable feature?

D. What would happen if light was excluded from celery stalks for a period prior to harvest?

E. Why do carrot roots exposed to light turn green in color?

F. What happens to weed growth when light is excluded?

G. Why aren't black coverings used on greenhouses?

V. Further Areas of Study

A. Observe plant behavior in different light intensities.

B. Germinate several bean seeds in the soil; expose some seeds to light while germinating.

C. Expose carrots to light after they have developed.

PHOTOSYNTHESIS

Exercise #1
Effect of Light on Chlorophyll Formation

I. Materials

A. Two containers and the media for germinating 25 to 50 bean seeds

B. 25 to 50 bean seeds

C. Light-proof area (complete darkness)

D. Labels and marking pencil

II. Procedure

A. Sow the seeds in the two containers. Label and date.

B. Germinate the seeds in the dark.

C. After the young plants have emerged from the seeds, move half of them into an illuminated environment.

III. Questions

A. Is there a reason why one set of plants has developed a green color?

B. Under what conditions can we grow plants on a commercial basis indoors?

C. What gas is given off by leaves during the day? During the night? Explain.

D. What is the role of chlorophyll in photosynthesis?

E. Are there commercial crops where lack of light is necessary? What are some of these?

F. Does light intensity have an effect? How?

TRAINEE WORKSHEET

Name

Date

UNIT: PHOTOSYNTHESIS - Exercise #1

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

V. Questions:

A. Is there a reason why one set of plants has developed a green color?

B. Under what conditions can we grow plants on a commercial basis indoors?

C. What gas is given off by leaves during the day? During the night? Explain.

D. What is the role of chlorophyll in photosynthesis?

E. Are there commercial crops where lack of light is necessary? What are some of these?

F. Does light intensity have an effect? How?

PHOTOSYNTHESIS

Exercise #2

Light and Chlorophyll - Essential to Photosynthesis

I. Materials

A. Two potted actively growing coleus plants (or similar plants)

B. Carbon paper or light-tight box (total darkness)

C. Ethyl alcohol, 95 percent

D. Hot plate, steam bath, or water bath

E. Iodine

F. Paper clips

II. Procedure

A. Cover half the leaves on a plant with pieces of carbon paper folded over the upper and lower surfaces and clipped in place. (Alternate procedure -- place one of the two coleus plants in a light-tight box or cabinet for several days. Leave the second plant in the light.)

B. Take a leaf or leaves from the plants that have been growing i the two different environmental conditions.

C. Mark each leaf with an identifying notch along the margin or the petiole as you remove it from a given environment, and m a note of the mark that corresponds with each environment.

D. Make a sketch of each leaf with its identifying marks after moving the treated leaves from the plants. Include variega areas.

E. Test each leaf for starch using the following method:

1. Kill the leaf by immersing it in boiling water for one mint

2. Extract the chlorophyll and other pigments by transferrin the leaf to hot 95 percent ethyl alcohol. Caution: the hot 95 percent ethyl alcohol used in this experiment should be

heated on an electric hot plate, in a steam bath or very carefully with a Bunsen burner in a bath of boiling water. Alcohol is very flammable.

3. When most of the pigment is extracted, dip the leaf in hot water again for three seconds to keep it from getting brittle.

4. Place the leaves in a Petri dish or saucer and cover with iodine solution for one minute.

5. Rinse the leaves in water and lay out for observations. A dark color in the leaf indicates the presence of starch. From where did this starch come?

6. Make another sketch of each leaf and indicate the dark areas.

7. Compare the sketches of each leaf, made before extracting the pigments, with the starch pattern. Was there starch present in all green parts? In all yellow parts?

III. Questions:

A. How does the presence of starch compare with the presence of chlorophyll in the leaves you studied?

B. What effect does the absence of light have on the presence of starch?

C. How does this information add to your knowledge of the factors involved in the process of photosynthesis?

D. What are some of the limitations of the techniques you have used in this exercise?

E. What effect does the presence or absence of light have on the occurrence of photosynthesis?

TRAINEE WORKSHEET

Name

Date

UNIT: PHOTOSYNTHESIS - Exercise #2

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

V. Questions:

A. How does the presence of starch compare with the presence of chlorophyll in the leaves you studied?

B. What effect does the absence of light have on the presence of starch?

C. How does this information add to your knowledge of the factors involved in the process of photosynthesis?

D. What are some of the limitations of the techniques you have used in this exercise?

E. What effect does the presence or absence of light have on the occurrence of photosynthesis?

REPRODUCTION

I. Title

Plant Propagation and Reproduction by Seeds

II. Introduction

One thing that distinguishes living things from non-living is that living things can reproduce themselves. Many plants reproduce by seeds or by spores. In some plants, leaves that drop onto the ground produce new plants; in others, new shoots develop from parts of the roots or from runners; in still others, branches that touch the ground take root and produce new plants.

A. What is the difference between sexual and asexual reproduction

B. Will seeds produce true to variety?

C. How does pollination relate to plant propagation?

D. What conditions allow a seed to grow?

E. How important is the seed coat?

F. How important is soil to seed germination?

G. What is a seed?

H. What are the advantages of budding and grafting?

III. Conclusion

Living things are able to perpetuate their own kind from a part of themselves. This may be either sexual or asexual reproduction.

The factors affecting germination are temperature, moisture, oxygen and possible light. When the conditions of dormancy are satisfied and the environmental conditions are favorable, a seed will germinate. Different kinds of seeds have specific temperature ranges at which they will germinate. Moisture softens the seed coat, swells the embryo, and starts other metabolic processes. Oxygen enters and increases respiration. Light may or may not be a factor.

Nutritive substances are to be found within the seed and are not taken from the environment. Soil is not a requirement for germination.

IV. Questions

A. Why is cross pollination necessary with corn?

B. Why is grafting and budding important to the fruit grower?

C. Why are some plants propagated by cuttings?

D. Explain why plants grown from seeds off the same parent plant can all be different?

E. How do conditions of storage, soil temperature and mechanical damage affect the viability of seeds?

F. What are the advantages of seed treatment and scarification of seeds?

G. What is dormancy?

REPRODUCTION

Exercise #1
Seed Germination

I. Materials

A. Planting containers (flats, cans, pots)

B. Germinating media

1. A fine, uniform mixture

2. Should hold water yet let excess water drain away

3. Should be free of weed seed, insects, and disease

4. Alkalinity or acidity levels dependent upon seeds to be germinated

5. "Cal Poly Mix" is suggested*

C. Suitable seeds

D. Soil fungicides

E. Hot water or bleach

II. Procedure

A. Fill flat, then firm and smooth soil.

B. Distribute seeds in uniform rows evenly spaced.

* -- "Cal Poly Mix" is a plant soil mixture composed of the following ingredients, proportions, and amounts:

Cal Poly Mix

two parts sand	three pounds hoof and horn meal**
two parts fir-bark	three pounds super phosphate**
one part clay loam	one pound of potassium sulfate**
one part aged manure	one pound dolomite lime**

** per cubic yard of total mixture desired

C. Cover seeds with fine soil (rule of thumb - cover four times the thickness of the seeds).

D. Water.

E. Place flat in warm location.

F. Keep seeds moist during germinations

G. Observe seeds until all have germinated.

III. Questions

A. Why are seeds covered only four times their diameter?

B. How may small seeds such as lettuce be evenly spaced?

C. What may happen if an excess of water is applied to the seed flat?

D. What is the purpose of the hot water or the bleach?

E. What method of propagation or reproduction is demonstrated by this exercise?

REPRODUCTION

Exercise #2
G[illegible]wing Avocado Seedlings

I. Materials

A. Roll [illegible] per, 18" width

B. Tar pot and brush

C. Metal cylinder, 4 3/4" diameter and 18" long

D. Avocado seeds (Mexican varieties preferred - Tapa Tapa, Dulce, etc.)

E. Silty loam soil (sterilized)

F. Tamp (instrument for firming soil)

G. Peat moss

II. Procedure

A. Cut tar paper in 18" lengths.

B. Form 18" tar paper cylinder using metal cylinder as form guide Seal paper edges together with tar.

C. Fill [illegible] r cylinder with moist soil.

1. [illegible] of soil in cylinder and tamp firmly.

2. Fill cylinder with soil lightly.

D. Plant one avocado seed.

1. Remove seed co[illegible]

[illegible] Cut [illegible]/8" from each end off the embryo. Be careful that cut does not exceed 1/8".

3. Plant embryo with pointed end up, just [illegible] the soil.

4. Cover with $\frac{1}{2}$" peat moss.

5. Water well.

6. Place in greenhouse.

7. Keep watered - do not over water.

8. Allow six months to grow.

9. Observe growth and treat plant for any pests or diseases that may occur.

10. Keep a record of each seed's growth.

III. Questions

A. Why remove the seed coat?

B. Why are the end cuts made?

C. Why must the end cuts be less than 1/8"?

D. Why should the soil be sterilized?

E. What factors may prevent seed germination?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Exercise #2

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

V. Questions:

A. Why remove the seed coat?

B. Why [illegible] end cuts made?

C. Why must the end cuts be less than 1/8"?

D. Why should the soil be sterilized?

E. What factors may prevent seed germination?

REPRODUCTION

Exercise #3
Propagating Citrus Seedlings

I. Materials

A. Seeds (Choose seeds from vigorous old trees. Commonly used seeds are sweet orange, Troyer citrange, Cleopatra mandrin, Trifoliate orange, and rough lemon.)

B. Suitable planting media (fine, well-drained "Cal Poly Mix"*)

C. Clean sand

D. Planting container (Redwood flat or LA lug box)

E. Aluminum sulfate

II. Procedure

A. Extract seeds from fruit just before planting. Wash and drain after extracting. If seeds cannot be planted immediately, dry on paper towel and store in refrigerator in a plastic bag.

B. Fill planting container with soil mix.

C. Apply $1\frac{1}{4}$ oz. aluminum sulfate per sq. ft. on surface of planting media.

D. Broadcast or space seeds in rows. Plant 200 seeds per box.

E. Cover with $\frac{1}{4}$" of sand.

F. Water well.

G. Place in greenhouse.

H. Keep moist, not wet.

I. Observe growth.

J. Seeds planted in December will be ready to be planted in nursery rows in April or May.

* See footnote in Exercise 1 -- Reproduction.

III. Questions

A. Why use seeds from older tree?

B. Why use aluminum sulfate?

C. How many seeds germinated?

D. What is your germination percentage?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTIO[illegible] [illegible]rcise #3

I. Objectives:

II. Procedure:

III. Obser[illegible] and R[illegible]lts:

IV. Concl[illegible]sio[illegible]s

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V. Questions:

A. Why use seeds from older trees?

B. Why use aluminum sulfate?

C. How many seeds germinated?

D. What is your germination percentage?

REPRODUCTION

Exercise #4
Asexual Reproduction - Cleft Grafting

I. Terminology

A. Scion - a shoot or branch, detached, containing buds.

B. Stock - the lower portion of plant to be grafted; the root system.

C. Cambium - a thin tissue of the plant between the bark and the wood.

II. Materials

A. Grafting knife

B. Grafting tool and mallet

C. Tree seal

D. Brushes

E. Deciduous tree

F. Scion wood (usually one year wood)

III. Procedure (Refer to Illustration)

A. Saw off branch squarely.

B. Split the branch down the center using grafting tool and mallet (make $1\frac{1}{2}$" to 2" cleft).

C. Drive wedge into center of cleft.

D. Cut 4" scion. Cut lower end wedge shaped. Outer side should be thicker than the inner side to insure cambium contact.

E. Carefully match cambium layers of scion and stock.

F. Carefully seal all cut surfaces with grafting wax to keep wounds from dehydration or disease infestations.

G. Allow time for buds to sprout and wounds to heal. Inspect grafts; determine successes or failures. Determine reasons for failure if any.

IV. Questions

A. Why must the cambium layers touch?

B. What are other methods of grafting?

C. Is there an advantage to grafting trees?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Exercise #4

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

V. Questions:

A. Why must the cambium layers touch?

B. What are other methods of grafting?

C. Is there an advantage to grafting trees?

REPRODUCTION

Exercise #5
Asexual Reproduction - "T" Budding

I. Terminology

A. Scion - a shoot or branch, detached, containing buds.

B. Stock - the lower portion of plant to be grafted; the root system.

C. Cambium - a thin tissue of the plant between the bark and the wood.

II. Materials

A. Budding knife

B. Budding tape

C. Bud wood (current year's growth)

III. Procedure (Refer to Illustration)

A. Make "T" incision $1\frac{1}{2}$" long in stock at desired location.

B. Cut shield bud. (Cut $1\frac{1}{4}$" long, deep enough to include a small amount of heartwood.)

C. Insert shield bud into "T" incision until it is beneath the bark.

D. Wrap firmly with budding tape.

IV. Questions

A. Why bud?

B. What are other methods of budding?

C. What type of bud should be used? Why?

D. What are the seasons when budding can best be accomplished?

E. Why do we insert the shield bud just beneath the bark?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Exercise #5

I. Objectives:

II. Procedures:

III. Observations and Results:

IV. Conclusions:

V: Questions:

A: Why bud?

B. What are other methods of budding?

C. What type of bud should be used? Why?

D. What are the seasons when budding can best be accomplished?

E. Why do we insert the shield bud just beneath the bark?

REPRODUCTION

Exercise #6
Asexual Reproduction - Tip Cuttings

I. Material

- A Perlite
- B. Redwood nursery flat
- C. Geranium cutting material
- D. Rooting hormone such as Rootone

II. Procedure

- A. Fill flat with Perlite.
- B. Make tip cuttings 3" to 6" long for greater carbohydrate concentrations at the basal part; midsection cuttings should be shorter. Make cuttings at least two nodes in length. Make angular cuts for easier insertion.
- C. Reduce leaf area 1/3 to 1/2 by removing lower leaves and trimming upper leaves. This reduces loss of water from transpiration and makes the cuttings easier to handle.
- D. Dip bottom of cuttings in rooting hormone.
- E. Insert cuttings in rooting media at an angle, one to two inches deep. Place cuttings as close together as leaves permit.
- F. Water and place in a warm area. Use mist propagator if available.
- G. Keep cuttings moist.
- H. Allow several weeks for cuttings to root.

III. Questions

A. When did the cuttings begin to callus?

B. How long before the cuttings rooted?

C. Why are cuts taken at an angle?

D. Why must the cuttings be kept moist?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Exercise #6

I. Objectives:

II. Procedure:

III. Observations and Results:

IV: Conclusions:

V. Questions:

A. When did the cuttings begin to callus?

B. How long before the cuttings rooted?

C. Why are cuts taken at an angle?

D. Why must the cuttings be kept moist?

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REPRODUCTION

Exercise #7
Whip Grafting - Avocado Seedlings

I. Materials

A. Avocado seedlings

B. Avocado scion - very mature (emerging buds). (Select pencil sized wood, about 8" long, including terminal buds.)

C. Budding knife

D. Budding tape

II. Procedure

A. Select seedling with stem about pencil size.

B. Select scion. Remove any flower buds.

C. Install whip graft 6" to 8" above soil level.

D. Tie with budding tape.

E. Return to greenhouse and observe two weeks.

III. Questions

A. Why should the whip graft be done 6" to 8" above soil level?

B. Explain why flower buds are removed?

C. Why select pencil size scion wood?

D. Why should the terminal bud be present?

E. What are the meanings of the following words?

1. Scion

2. Root stock

3. Cambium layer

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Exercise #7

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

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V. Questions:

A. Why should the whip graft be done 6" to 8" above soil level?

B. Explain why flower buds are removed.

C. Why select pencil size scion wood?

D. Why should the terminal bud be present?

E. What are the meanings of the following words?

1. Scion

2. Root stock

3. Cambium layer

REPRODUCTION

Exercise #8
Citrus Budding

I. Materials

A. Citrus seedlings

B. Budwood

C. Budding knife

D. Budding tape

II. Procedure

A. Make a $1\frac{1}{2}$" long "T" incision about 8" above the ground on the side of the citrus seedling.

B. Cut a shield bud from the budwood $1\frac{1}{4}$" long. Include a small amount of heartwood.

C. Insert the shield put into the "T" incision until the entire shield is beneath the bark.

D. Wrap tightly with budding tape.

III. Questions

A. Why is the "T" cut taken on the north side of the tree?

B. What type of bud should be used? Why?

C. How long did it take for the bud to grow?

TRAINEE WORKSHEET

Name

Date

UNIT: REPRODUCTION - Ex rcise #8

I. Objectives:

II. Procedure:

III. Observations and Results:

IV. Conclusions:

V. Questions:

A. Why is the "T" cut taken on the north side of the tree?

B. What type of bud should be used? Why?

C. How long did it take for the bud to grow?

TRANSPIRATION

I. Title

Water Movement from the Leaves - A Type of Diffusion

II. Introduction (Refer to unit on Diffusion for complete introduction.)

Of all the environmental factors that affect plant life, none is more important than water.

A. Why must we continually irrigate?

B. Where does the water in the plant go?

C. What causes a plant to wilt?

D. Why do we cut back a plant top when transplanting?

III. Conclusion

All plants lose water as vapor through the stems and leaves. Whenever the uptake of water by the roots is slower than the rate of transpiration, wilting will be initiated.

IV. Questions

A. How can cover crops control moisture in the soil?

B. To compensate for root damage and to lessen water uptake when transplanting, a common practice is to cut back aerial portion of some plants. Why?

C. In many semi-desert areas, plastic tents can be used to cover plants. The idea is to collect water vapor given off by the plant. This moisture could run off into troughs and be used for watering livestock and game. Is it a very practical idea? Why?

TRANSPIRATION
FIGURE 25

D. When soil and atmospheric humidity are high, fruits tend to absorb more water than cells are capable of holding. What happens?

E. How can wind, soil type, humidity and temperature affect the frequency and amount of irrigation?

V. Further Areas of Study

A. Expose one plant to a fan or air circulating device and place another plant in a sheltered area. Water and weigh each plant and container at start of exercise and after 24 hours. Account for any differences in weights.

B. Stomato location - cellulose-tape technique to remove the epidermis.

C. Obtain several small plants in nonporous containers. Seal the soil surface with plastic or foil to prevent soil water evaporation. Weigh each potted plant and subject one to 75° F for a 24 hour period. Other environmental conditions should be the same for the other plants. Weigh the plants again and calculate the percentage of water lost for each plant. Contrast the results and explain any differences.

D. The plant's structure such as exposed leaf area can affect the rate of transpiration.

E. Fill several pots with various soil types, ranging from sand to clay. Weigh the pots and then saturate each with water and allow them to drain freely for 48 hours. Calculate the percentage of water retained by each in contrast to the original weight of the soil. Determine the best type of soil for water holding. Tell why you would choose one soil type rather than some other for growing plants.

TRANSPIRATION

Exercise #1
Plants Transpire

I. Materials

A. A growing plant in any size container or growing in a convenient location.

B. Plastic bag or sheet of clear plastic that will cover the plant or a stem.

C. String or rubber band.

II. Procedure

A. Be certain the plant has been watered.

B. Cover the leaves and stems with the plastic bag or other material.

C. Tie material securely at base. Take care not to injure the stem.

III. Questions

A. Note any water condensation on the inner surface of the bag. Why does this occur?

B. Does light intensity have an effect? How?

TRAINEE WORKSHEET

Name

Date

UNIT: TRANSPIRATION - Exercise #1

I. Objectives:

II. Procedure:

III. Observations and Results

IV. Conclusions:

V. Questions:

A. Note any water condensation on the inner surfaces of the bag. Why does this occur?

B. Does light intensity have an effect? How?

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