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# CITRUS CULTURE IN THE LOWER RIO GRANDE VALLEY OF TEXAS

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## ACKNOWLEDGMENT

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THE AUTHORS

May 1, 1924.

The demand for this bulletin having exhausted the supply, the present Extension Horticulturist has revised the original text slightly for re-publication. Acknowledgment for the material used is made to the original authors, A. T. Potts, former Chief, Division of Horticulture, Texas Agricultural Experiment Station, and A. P. Swallow, former Horticulturist, Texas A. and M. College Extension Service.
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## TABLE OF CONTENTS

## TABLE OF CONTENTS (Continued)

# CITRUS FRUIT CULTURE IN THE RIO GRANDE VALLEY OF TEXAS

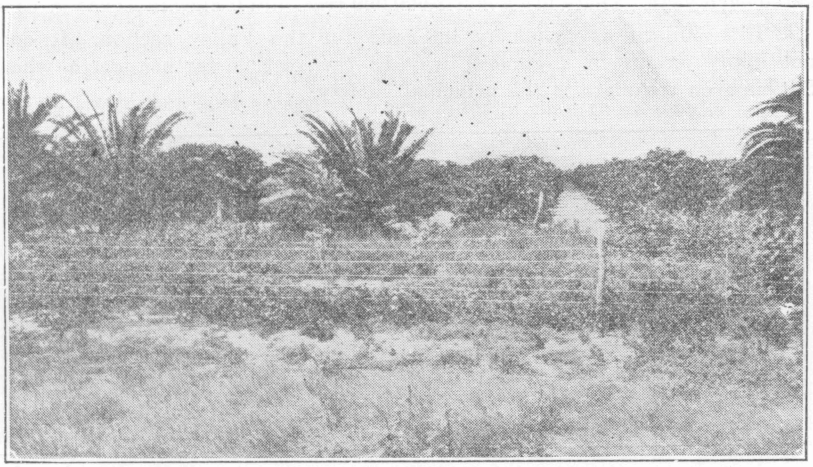

Fig. 1. A Valley grove and windbreak.

## DEVELOPMENT OF THE CITRUS INDUSTRY

The commercial citrus industry of Texas is young, although citrus fruits for home use have been grown in the state for many years. Many of these scattered old trees are still growing and bearing good crops.

Of all horticultural lines in America, the growth of the citrus industry has been the most remarkable. It has grown steadily through many set-backs, until today, it is probably the best organized fresh fruit industry in the country. It has changed from the production of a few sour and inferior varieties to high quality, tasty fruits. Grape fruit, practically unknown a few years ago, is now used liberally in all sections of the country, with an ever increasing demand. Once nearly all the lemons used in the United States were imported. We are today growing over 80 per cent. of our consumption.

The U. S. census report for Texas for 1910 gives a total of 883,406 citrus trees in Texas, while the 1920 report gives a total of only 123,951 bearing trees. The great majority of the trees in 1910 were Satsumas in the Galveston-Houston section, but a few other varieties were found. Citrus canker and the freeze of 1917-1918 were the main factors in reducing the number of trees so materially between 1910 and 1920. The early growers in the Rio Grande Valley found that the trifoliata and Satsuma did not seem so well adapted to their conditions. The round oranges gave very promising results, especially if sour orange root stock was used. The chief development of the citrus industry in Texas has for the past few years been in the Lower Rio Grande Valley and most of the trees reported for 1920 are to be found in Cameron, Hidalgo and Brooks Counties, with smaller plantings being made northeastward in Willacy, Kleberg, Jim Wells, Nueces, San Patricio, and Refugio counties and northwestward in

Webb, Dimmit, La Salle, and Frio counties. Citrus growing in the lower Rio Grande Valley has become well established, and if the growers give proper care and attention to their trees, thousands of cars of citrus will be marketed each year. There are about 3,000,000 trees of all ages in Texas in 1927.

This bulletin is primarily intended for the Valley section. It does not apply except in a general way to the section farther north where Satsuma on trifoliata is the principal variety.

Fig. 2. A Satusma grove in the upper costal section.

## SELECTION OF SITE

Under this head we will consider soil, irrigation, water drainage, air drainage, frost damage, and other factors the grower may expect to meet in developing a grove in the Rio Grande Valley.

**Soil**—Citrus trees will grow on many types of soil. They are found growing upon the light sands of Florida and the stiff clays of California. The silty formation of the Rio Grande Valley is good citrus soil, especially for trees budded on sour orange roots. Even in this small area, however, there is a wide variation in soils. Some spots are unfit for citrus because of too great an alkali content, others because of lack of drainage. Soil survey maps will soon be available that will give much valuable data upon the character and uses of Valley soils. A soil rich in humus is the most desirable and it may vary from sandy loam to medium heavy clay. A study of the groves in any section will give the best information as to the adaptability of that soil to citrus production. At this time the greatest development is upon the lighter soils.

**Water**—It is estimated that about 40 inches of water annually in rain and irrigation is necessary to properly supply the trees. Thus the next most important factor is irrigation. The prospective grower should in all cases be sure that the water for irrigation will be available for his orchard.

**Drainage**—While it is essential that there be plenty of water, it is equally important that the orchard be located where it will be freely and completely drained. Trees that do not have this drainage may soon become affected with gum disease or other troubles. No orchard will remain profitable for many years with a high water table or with a nearly

saturated soil. Drainage is always a problem in low flat areas and with the torrential rains that often visit a semi-tropical country the Valley grower needs to give this water careful consideration. The water table should be several feet below the surface at all times of the year.

**Frost**—Cold air drains away from the more elevated land and settles in the lower spots. For this reason, it is not uncommon to find orchards a short distance apart varying greatly in the amount of frost damage. Those on the higher land escape with less damage than those on the lower land.

**Alkali**—Alkali is a term applied to the accumulation of soluble salts in the surface soil in sufficient amounts to cause injury to plants. These soluble materials are brought to the surface and left when the soil moisture evaporates. The water from the Rio Grande used in irrigation does not, as a rule, contain dangerous amounts of alkali. Conditions in the Valley most favorable for the formation of alkali are over irrigation and poor drainage.

Citrus is particularly susceptible to alkali. Coit* says: "Where the soil contains two-tenths of one per cent of total salts, the trees are likely to be injuriously affected. A total salt content of less than one-tenth of one per cent is usually considered safe." Sodium chloride is the principle salt found in the Valley.

## CITRUS PROPAGATION

As the citrus fruit industry develops in the Valley, it becomes evident that sour orange is the most satisfactory root stock obtainable at this time. There are instances of trees budded on root stocks other than sour orange which have proven fairly productive, but these are not common.

The following tabulation of the rank of qualities of the more common root stocks used in Florida was compiled by Mr. F. M. O'Byrne, Chief Nursery Inspector, for Florida conditions and is here used by courtesy of Mr. O'Byrne. These same advantages and disadvantages seem to apply also to the Valley and each can be readily determined from these tables.

**Adaptability of Principal Citrus Stocks as Rated by F. M. O'Byrne.**

| | Lemon | Grapefruit | Sour Orange |
|---|---|---|---|
| 1. Rapidity of growth | 1 | 2 | 3 |
| 2. Texture and quality of fruit | 3 | 2 | 1 |
| 3. Prolificacy | 1 | 3 | 2 |
| 4. Retention of fruit and juice | 3 | 2 | 1 |
| 5. Resistance to cold | 3 | 2 | 1 |
| 6. Resistance to root disease | 3 | 2 | 1 |
| 7. Resistance to fungus disease | 3 | 2 | 1 |
| 8. Adaptability to thirsty light soil | 1 | 2 | 3 |
| 9. Adaptability to heavy hammock, and reclaimed land with clay sub-soil | 3 | 2 | 1 |

*Coit J. E., "Citrus Fruits," p. 144.

The following advantages and disadvantages of the several stocks should be of interest.

### Sour Orange....

| Advantages | Disadvantages |
|---|---|
| 1. Tolerant to cold | 1. Slow growing as compared to rough lemon. |
| 2. Tolerant to water. | 2. Tree smaller than on rough lemon. |
| 3. Produces extra fine fruit: smooth thin-skinned, juicy, heavy, character, high color. | 3. Not as prolific as rough lemon. |
| 4. Very resistant to foot rot. | 4. Will not grow well on light soils. |
| 5. Long-lived. | 5. A failure for Satsuma. |
| 6. Adapted to rich, heavy soils. | 6. Fruits must be handled with care. |
| 7. Early crops are good. | 7. (Subject to scab). |
| 8. Sprouts readily if frozen down. | |
| 9. Holds fruit a long time with small natural dropping. | |
| 10. Fruit doesn't dry at stem end. | |

### Rough Lemon

| Advantages | Disadvantages |
|---|---|
| 1. Very rapid grower. | 1. Subject to cold damage. |
| 2. Adapted to light, sandy soil. | 2. Subject to gum disease. |
| 3. Good tap root. | 3. Early crops poor quality. |
| 4. Prolific. | 4. Fruit sour, lacks character. |
| 5. Comes into bearing early. | 5. Skin thick and coarser than sour orange. Has more rag. |
| 6. Fruit ships well. | 6. Slow to start in spring. |
| 7. Easily handled in nursery. | 7. Does not stand wet feet. |
| 8. Will stand drouth splendidly. | 8. Trees short lived. |
| | 9. Doesn't do well on rich soil. |
| | 10. Subject to scab. |

### Citrus Trifoliata

| Advantages | Disadvantages |
|---|---|
| 1. Resistant to cold. | 1. Tree slow-growing. |
| 2. Fruit juicy and good quality. | 2. Not good on high, dry calcareous soils. |
| 3. Prolific for its size. | 3. Short lived. |
| 4. Precocious. | 4. Hard to handle account of thorn. |
| 5. Subject to San Jose scale. | 5. Subject to San Jose Scale. |
| 6. Slow to start in spring. | |
| 7. Does well on clay soil or subsoil. | |

The U. S. Department of Agriculture and the various state Experiment Stations are constantly in search of new stock for citrus fruits. It is quite likely that more desirable sorts than we now have will be discovered. Sweet orange and grape fruit, and in some cases, limes, have been used for stocks in addition to those mentioned above. None of these have proven entirely satisfactory. The Cleopatra Mandarin is receiving considerable attention in Florida at this time.

**Seed for Stock**—Sour orange seed from which the stocks are grown are obtained from Florida, Cuba or other warm regions. In past years the bulk of this seed has come from the wild trees of Florida but owing to the rapid development of that state practically all of these trees have been destroyed. The Florida sour orange seed now comes from "door-yard" trees or from orchard trees that have sent up shoots from the stock. The sour orange seed obtained from Valley trees is as satisfactory as the average commercial stock from other sections. If they were taken from only the best trees, it is quite likely they would be much superior to an unselected lot. *H. J. Webber has shown that only fairly vigorous and large seedlings should be used as stocks and that the smaller and weaker seedlings and buds rarely produce a satisfactory tree.

**Growing Seedlings**—It is generally more satisfactory to buy the trees from a reputable nursery but owing to the heavy demand trees are often scarce and high in price. The following paragraphs give briefly the methods that may follow if it seems desirable for the orchardist to grow his own trees.

Seed should be planted about the latter part of February. It is best to soak them for a few days in soft water before planting. The water will require changing at least twice a day, if the seeds begin to ferment. After the soaking period, the seed should be planted at once.

There are several methods used in handling the seed beds. Two of these will be briefly outlined. In all cases the beds are given about half shade from the time of seeding until the plants are several months old.

**Outside Beds**—If it is planned to use hand cultivation, the rows should be on a slight ridge and about a foot apart, but where a large amount

Fig. 3. An outside seed bed.

*Webber, Herbert J., "Selection of Stocks in Citrus Propagation," Calif. Expt. Sta. Bul. No. 317, 1920.

of seed is planted, it is better to have the ridges 32 inches apart and use horse drawn tools. The seed should be planted about 1 inch deep and covered with moist sandy loam. About three seed should be sowed to the inch.

The seed bed must be kept very moist until the seedlings come up which will require from three to four weeks. Cover the seedlings with a partial shade until the middle of the summer, after which time, the shade should be gradually reduced. The young seedlings are very tender and unless they are shaded, will be killed by the hot sun. This partial shade is best made with laths or 1 x 2 inch lumber allowing an inch or two between the laths. Some growers have successfully used the leaves of the palm for a cheap shade where only a few seedlings are grown. Lay the leaves over the rows where the seed are planted, using care to see that the upper sides of the leaves are faced to the ground, and the mid-rib directly over the row. Placing the leaves this way raises the mid-rib a few inches from the ground, making an excellent partial shade. Other growers use a section of picket fence or brush stretched over a frame work above the seedlings. Keep the seedlings well cultivated and irrigated to promote vigorous growth.

**Lath Houses**--Nurserymen and other large growers frequently find it more satisfactory to construct a framework over the seed beds and to cover this with plasterer's lath. This structure is of a semi-permanent nature and high enough to permit ease in handling the plants. In this case the seed are planted on beds several feet wide with a combination walk and irrigation ditch between. The beds are leveled, firmed and the seed scattered broadcast, one seed about every square inch. The seed are now covered with about one inch of pure sand. The beds are watered by sprinkling or by capillarity from the walk ditch mentioned above.

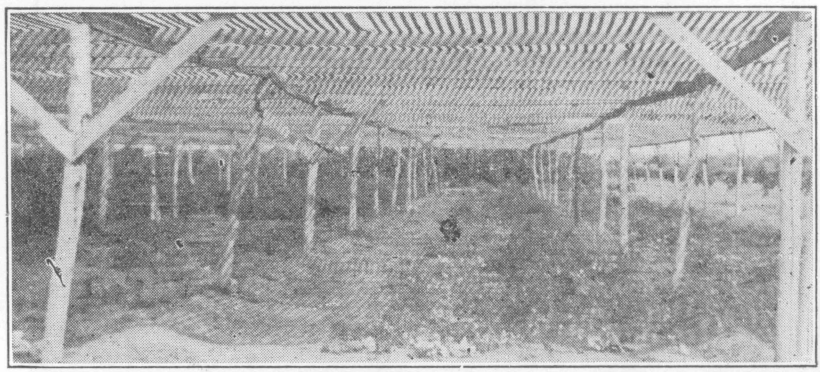

Fig. 4. Seedbed protected by lath.

Usually during the following winter and spring the seedlings may be planted out in the nursery row. The inferior plants should be discarded at this time. The other can then be grouped into three

sizes and each size planted in separate rows. The larger seedlings always develop into the largest trees. The other two sizes, medium and small, will usually maintain their same relative size throughout the life of the trees.

The roots and branches of the seedlings may be cut back about a third when they are transplanted. Remove all the leaves. Set the seedlings 14 inches apart in the rows and make the rows about four feet wide. Make sure that the plants have an abundant supply of water when they are transplanted, and that the soil is kept moist until the seedlings are well established. Do not expose the roots to the direct rays of the sun or leave them out in the air for any length of time between digging and planting. If special care is used in handling the seeds and seedlings, a large percentage of those planted will be brought through to budding time. With proper attention, a large number of seedlings will be big enough to be budded the following summer and fall. All should be ready when two years old. One pound contains about two thousand seed and should give from twelve to fourteen hundred plants.

## BUD SELECTION

There is a great degree of variation in the same varieties of citrus fruits. Each tree in the orchard is more or less of an individual in type and bearing traits.*

Therefore, in selecting buds, special consideration should be given to the type and known characteristics of the tree from which they are to be taken. Only those trees and branches having the most desirable qualities should be used as sources of bud wood, for the same characteristics will continue in the young budded trees.

It is not the general practice of the majority of growers to bud their own stock. In many cases, it is advisable, if time is no object. Home grown and home budded trees have the advantage of known root stock, quality and variety of buds used.

Budding may be done at any time when the bark slips easily. Early spring is the season when most nurserymen prefer to do the bulk of this work. The ordinary shield (or T.) method is used.

## PLANTING THE ORCHARD

**Varieties****—The selection of varieties should be given careful consideration.

The grove is to be maintained for many years so that this matter deserves more attention than is given to short seasoned crops. At this time Texas has no ideal variety of citrus, though there are a number that are fairly satisfactory. The search for better varieties has given rise to the planting of many sorts. To a limited extent this may be desired but as a rule extensive plantings of unproven sorts should be discouraged. The Valley must market as a unit. Marketing is complicated by numerous varieties. The fact that California uses only a few varieties is one of the reasons for their outstanding marketing success.

*Shamel. A. D., "A Study of the Improvement of Citrus Fruits Through Bud Selection." U. S. D. A. Plant Ind. Cir. No. 77, 1911.

**A detailed pomological description of citrus varieties is beyond the scope of this bulletin. Local conditions, stocks and the natural variability of citrus cause much confusion, so that the grower should put a broad interpretation upon catalogue description.

We would like to select varieties that would give us successive crops for twelve months. This would be the ideal condition but so far no region has been able to entirely achieve it.

Oranges—The Navel—Valencia orange combination as used by the California growers and the Parson Brown—Pineapple—Valencia groups of Florida come near to filling the requirements. At this time the Florida varieties just mentioned seem best for Texas. However, it is quite likely other varieties may be found more desirable. The Navel is deservedly called the "King of Oranges" and its use is highly desirable. There are a few trees of this sort bearing in the Valley of unsurpassed quality, but as a general thing it is not prolific and the fruit is large, coarse and dry. Propagation from these trees of high merit will quite likely establish the Navel in Texas. The grower should confine his plantings to known sorts, even if not ideal, rather than to attempt to make a test ground of his grove. Let the Experiment Station prove new sorts.

**Mandarin Type**—Small plantings of one or two varieties of the Mandarin Orange group may be found profitable. The Dancy (Tangerine) and King both do well in the Valley. The Satsuma is the best of this group but so far it has not been successful in the Valley. It is, however, grown largely in the upper coast section and thousands of acres of it are being planted in southern Alabama and northern Florida. The chief reasons for this failure seem to be due to the necessity of budding it on Citrus Trifoliata and this root stock does not do well in the Valley section. It is fairly satisfactory upon rough lemon and sweet stock so that it may one day find a place in our commercial plantings. All of the Mandarins are considered as more or less fancy fruits and are not extensively grown where the standard sorts do well.

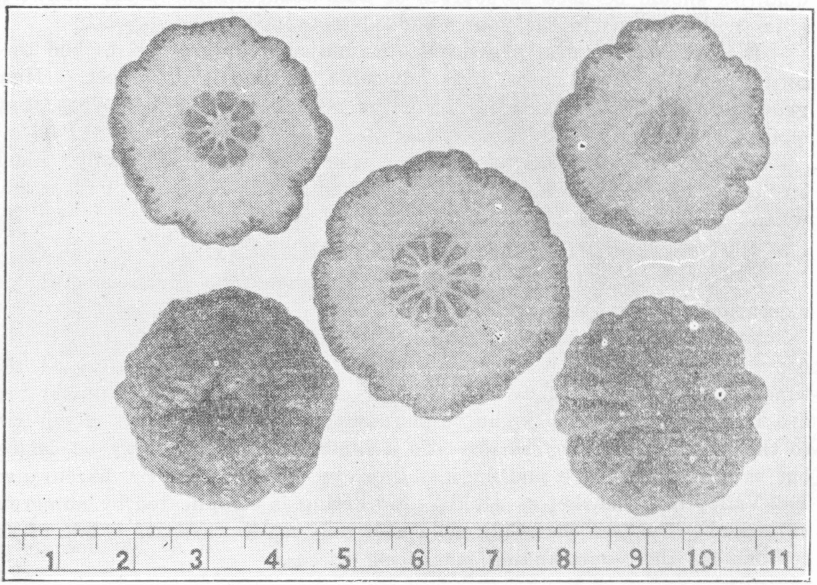


Fig. 5. Fruits from a Valencia orange tree. Careful bud selection would prevent this.

**Grapefruit**—Of the grapefruit, Marsh and Duncan seem best at this time. The Marsh is deservedly popular because of its all-around qualities but is hardly as prolific or cold resistant as Duncan. Walters is a good early sort, while McCarty is one of the latest.

**Kumquats**—The several varieties of Kumquats may be grown. Neiva is a relatively new sort and quite desirable.

**Lemons**—Lemons and limes are very easily injured by cold. Large plantings of these should not be made at this time except by experienced men. Of the lemons, Eureka is the best, followed by Lisbon and Villa Franka. There is a new lemon (Myers) recently introduced by the U. S. Department of Agriculture from China that is said to be hardy and to be very promising.

**Limes**—There are some strains of the Mexican lime that are quite large and said to be fairly resistant to cold. The Tahiti is another large fruited variety.

**Selection of the Trees**—As a general thing young plants of all kinds are more easily moved than older ones. Citrus are no exception to this rule. However, where balled stock is used quite old trees may be successfully moved and this is frequently done where it is desired to make a quick show or for beauty.

The trees for your grove should be selected with care. The plantation is for a generation and so deserves the best judgment. Other things being equal, trees should be bought from the local nurseryman. He has a very definite interest in the success of your planting and will be accessible if there is a "comeback." His trees are selected with a view of meeting local demands and conditions and are acclimated.

The price of trees is based upon several different factors or a combination of them, the height, the diameter (a few inches above the union) or the age may be used. It is generally best to use a combination of all three. A good one-year old bud should be from 5-8 to 3-4 inches in diameter. The nurserymen of California and Florida head the trees at about thirty inches in height, the Valley growers at about eighteen to twenty-four inches. The young tree should have from three to five well spaced branches upon the upper nine inches. The roots should be short, fibrous, and numerous. Citrus has a well-defined tap root. When this is cut at transplanting one or more are frequently formed to take its place. Each species of citrus has a more or less characteristic root system. Typical sour orange is not like typical rough lemon but as very few of either are what could be called typical, the root system can rarely be used to distinguish the two species.

**Soil Preparation**—The cost of the preparation of Valley lands for an irrigated orchard is frequently under estimated. Citrus trees, however, live to a great age so that any reasonable expenditure to facilitate future operations is justified.

At this time, it costs from about fifteen dollars to thirty dollars per acre to clear and grub. If citrus trees are to be planted within the first year it is important to remove as many roots and small branches as practical, as these are breeding places for termites (white ants) that may be very injurious to the young trees.

Levelling and laying out field ditches will take skill and considerable time. It will generally pay the average grower to employ a competent engineer to lay off his ditches and to indicate where grading and leveling should be done. Time and money spent at this time will mean economy in the years to come. In levelling, the moving of even a few inches of soil over an acre or so is expensive but the orchard should not be set until all the area waters evenly and quickly.

The plowing and fitting of the land for setting the trees should start at such time as to insure getting the soil into good condition. To attempt to prepare the land after the trees are set is rarely successful and always expensive. The land should be plowed as deeply as practical. This should be followed by the disk, or other pulverizing tools, frequently enough to insure a layer of soil readily penetrable by moisture and tree roots. The previous cropping may be so arranged as to aid materially in getting the soil into good physical condition.

**Laying Out the Orchard**—There are several methods of laying out the grove so as to get the trees properly spaced and the rows straight. Two of these will be mentioned.

The Square System is the most simple and most generally used. By the square method the tree rows are laid off parallel to a base line and, of course, to each other. The trees are set the same distance apart as the rows are apart. The rows of trees intersect one another at a right angle so that cultivation may be carried on in two directions. This method does not equally distribute the land on all sides of the tree. Either the trees are too close on the sides of the square or they are too far apart on the diagonal.

The Hexagonal System gives even distribution, every tree being exactly the same distance from every other tree. To lay out an orchard by this method a base line is established along the side of the land and stakes are set for the trees, say, every twenty feet. Using a wire and stick for a compass and the distance the trees are to be apart as a radius; arcs are struck off on the ground from each stake set in the first row. Where these arcs cross a tree will stand. This gives a six sided figure with a tree in each corner and a seventh in the middle (see figure 7). If the trees are to be twenty-five feet apart the second row will be only about twenty-two feet from the first row. Cultivation can be conveniently done in three directions which materially reduces the hand work. By this method about fifteen per cent. more trees can be set to the acre than by the square method. Though a little more trouble this difference can not be overlooked on high priced land.

**Setting the Trees**—Citrus trees, in common with others, show a change in color just above the roots. This indicates how deep the tree stood in the nursery and is a guide to proper depth of setting. Trees generally do best when this is observed.

Trees come from the nursery with bare roots or with a ball of earth weighing 30 to 40 pounds about the roots ("Balled stock"). The bare rooted trees are cheaper but the balled stock generally grows off faster and makes the best appearance. Bare rooted trees should be unpacked at once,

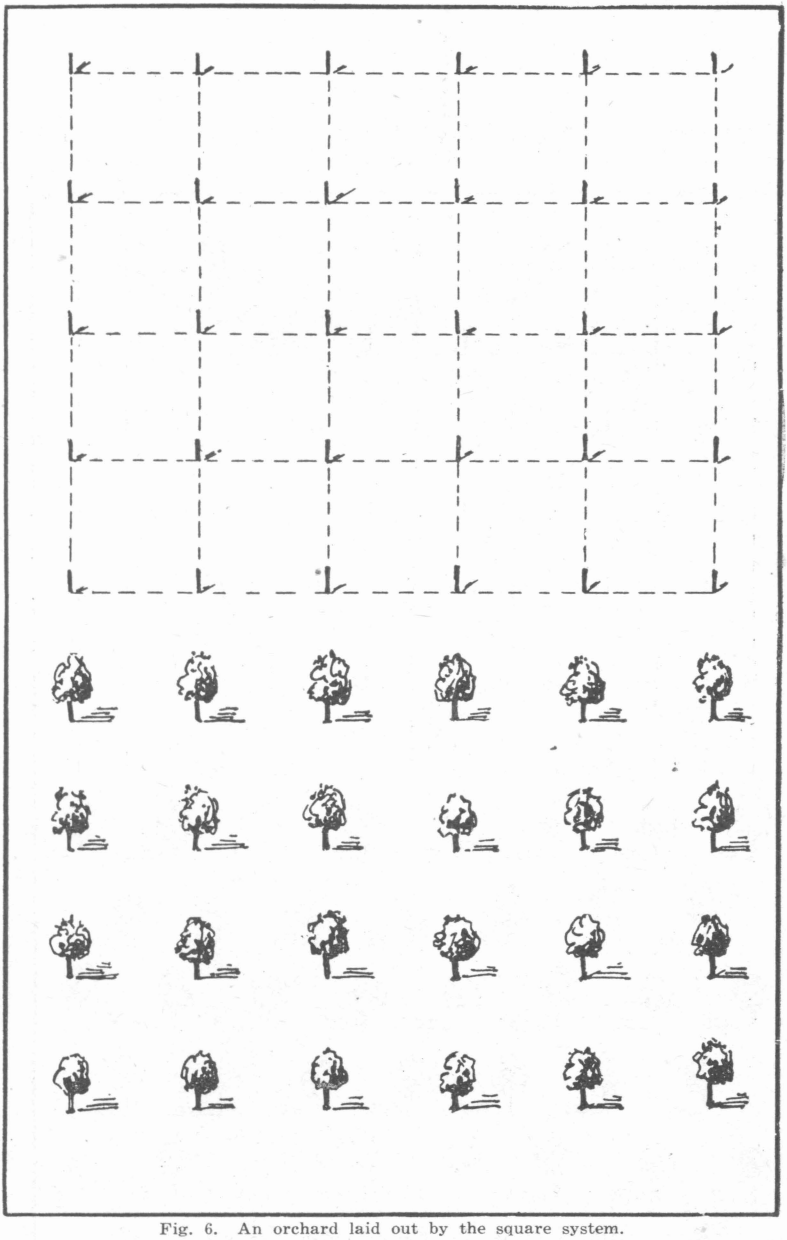

Fig. 6. An orchard laid out by the square system.

carefully inspected for insects and diseases, and the roots placed in a furrow and covered with earth. They should receive a good watering at this time and every few days as needed. The balled trees should be inspected, placed in a cool shaded place and the sacks kept wet. If very dry they may be placed in a furrow of water for a few hours.

Every precaution should be taken to see that only sound trees go into the orchard. Care at this time may result in the saving of much money

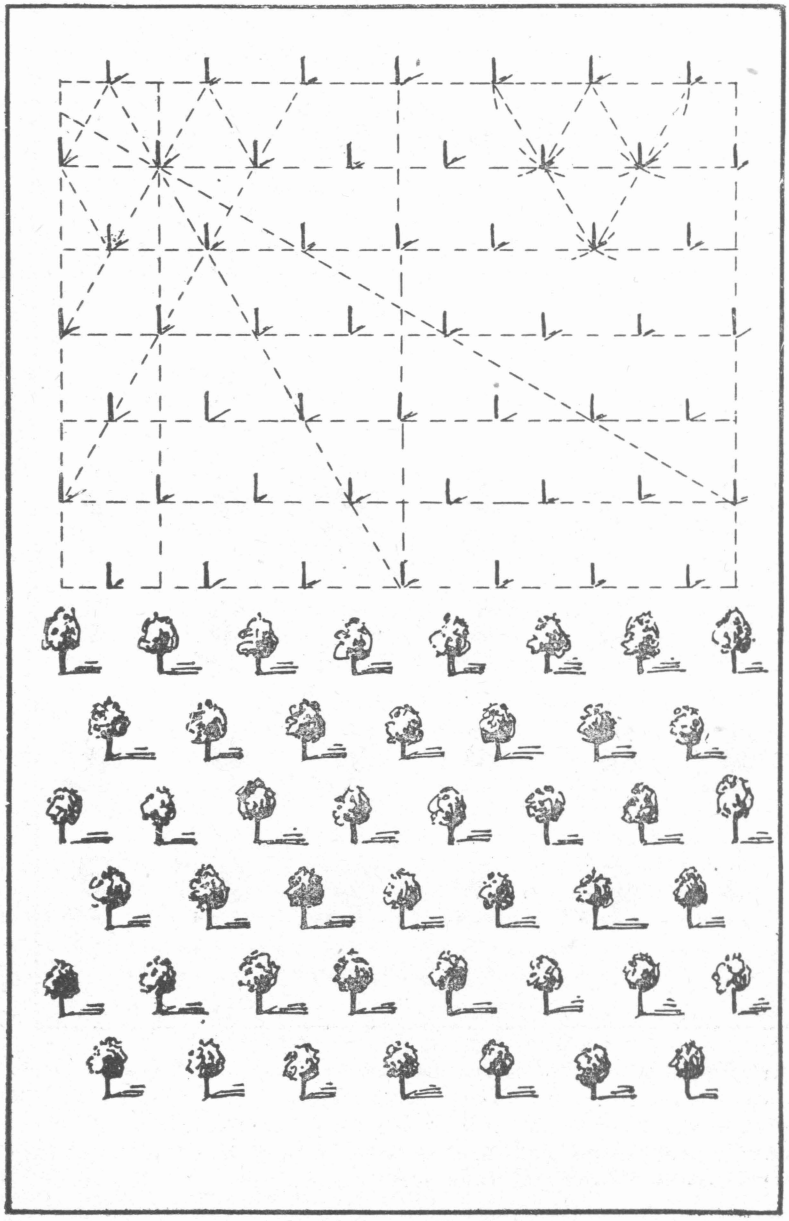

Fig. 1. An orchard laid out by the Hexagonal system

and disappointment later. Questionable trees should be isolated until the trouble can be determined.

The holes for the trees should be large enough to admit the roots in their natural position without crowding. The depth of the holes should be regulated to permit the tree to stand just as it was in the nursery row. With balled stock, the top of the earth around the roots should be set level with the soil.

Practically all citrus is budded so that the little tree consists of two parts—the lower part of the stem and the roots, and the upper part of the stem and the branches. One of the reasons for having a tree like this is that it has been found that certain roots are resistant to disease. For example, sour orange root is especially resistant to the gum disease, while some of the other citrus roots are not. So if we plant a tree with sour orange roots deeper than it stood in the nursery row we stand a chance to lose all the good gained by a resistant stock.

When filling in the earth around the roots it is well to discard the soil dug from the bottom of the hole and use only surface soil. This should be worked around the roots carefully so as to secure close contact. After the hole is nearly filled the earth may be firmed with the feet, or better, by pouring in a bucket or two of water, or turning in irrigation water. After this the hole is filled, level with the surrounding field.

## WINDBREAKS

Windbreaks are used to check the speed of the wind through the orchards. In one case they are planted on the side from which the prevailing wind is expected. In another case they are used as a check to the wind in orchard heating operations.

Fig. 8. A young tree showing the effect of wind.

The strong southwest winds that prevail in the Valley do considerable injury to the trees in young orchards as well as those of bearing age unless they are protected by windbreaks.

The Texas cold periods usually start with a strong wind from the north or northwest. The temperature usually does not fall below the danger

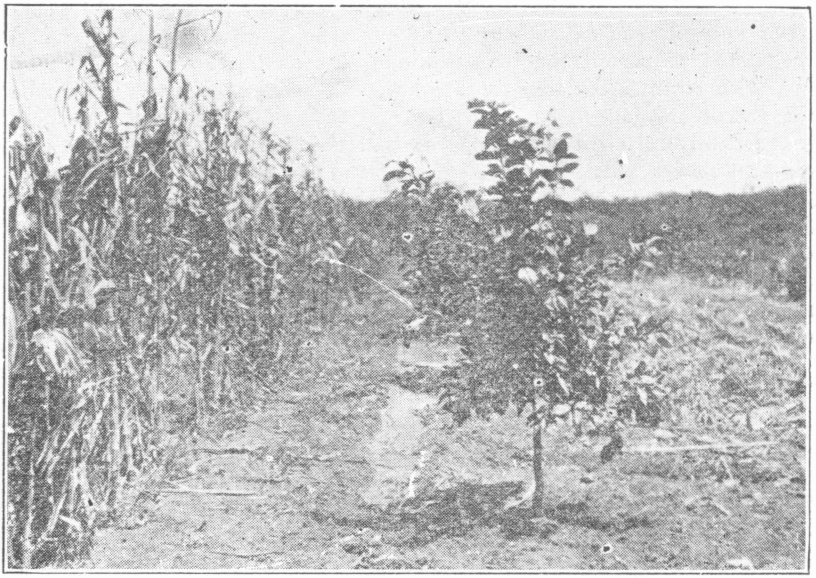

Fig. 9. Young tree protected by corn windbreak.

point in the Valley until this has continued for several hours. Little can be done at heating during these high winds, but a wind check will be found of material assistance in maintaining the temperature of the orchard and in the conservation of fuel.

Planting windbreaks should be a part of every orchardist's plan. The windbreak does not need to be one that makes a dense hedge, but rather a series of obstacles which will allow the wind to sift through, making a slow moving current of air through the orchard at all times. This allows more perfect heating in time of frost, and will prevent the damage done by extra strong winds that whip the leaves and fruit. The best type of trees for a windbreak are those that will grow tall and do not spread too widely. A variety that will not harbor pests that are injurious to citrus is most preferable. For example, the Oleander is objectionable because it is a host to many of the citrus scale insects. Windbreaks are either temporary or permanent according to the type of plant selected.

**Corn**—This is doubtless the best temporary windbreak, (**not broom corn**). It should be planted in the spring, three or four rows of corn between each row of trees, if the trees are planted at least 20 feet apart. It is to be kept in mind that a crop of corn is not the final object of this

Fig. 10. The fan palm makes an attractive windbreak.

plan. It is merely to furnish a temporary windbreak for the young trees that have been recently set. The profit from the corn is a secondary consideration, but may add a little income. Plant the corn with the nearest rows at least five feet from the trees. Allow the corn to remain in the orchard as long as possible, and in the early fall the stalks may be plowed under to add humus to the soil. The mistake of not irrigating the trees after the corn crop is mature should not be made. Failure of the grower to irrigate after the corn has matured may do material damage to the young trees. It is only advisable to plant corn in the orchards for the first two or three years.

**Athel (Evergreen Salt Cedar)**—Evergreen Salt Cedar is becoming very popular as a permanent windbreak. It is resistant to adverse conditions, makes a very rapid growth, and does not become too dense. Other windbreaks that are commonly used in the Rio Grande Valley are Bamboo, Eucalyptus, Palms and Bananas. It is important that sufficient space be allowed between the plants used as windbreaks to permit a complete circulation of air, else an air pocket may be formed if the windbreak is planted too close.

Those who are planning to plant an orchard whether it be next year or still further in the future, should start their permanent windbreaks at once. When the orchard is set out the windbreaks will be ready to function while the trees are young and need them most.

## CULTURE

The success of the orchard will largely depend on the skill and intelligence used in handling the soil. The care and management of the grove is one of the most important parts of citrus production. Numbers of orchard ills may be started or intensified by failure in this regard.

The lighter soils are much easier and cheaper to handle. The stiff soils require a great deal more skill to keep in good condition but will produce satisfactorily if properly handled.

In all cases the system of cultivation must be determined by the requirement of each particular soil, but there are some fundamental practices that apply to all soils.

Benefits of cultivation: (1) Tillage improves the physical condition of the soil by loosening it and thereby greatly increasing the feeding area of the plant roots. (2) Cultivation increases the water holding capacity of the soil by permitting rain and irrigation water to penetrate more readily and by checking evaporation. (3) It permits a flow of air into and out of the soil. Air is an aid to soil organisms in rendering plant food available and is essential for root growth. (4) It increases chemical action in the soil thus rendering more plant food available. (5) Cultivation keeps down weed growth so as to save plant food and moisture.

There are cases where trees have been grown with no cultivation and yet the growth and production is all that could be desired. For the most part these trees are grown under exceptional conditions that cannot be duplicated in the orchard.

Fig. 11. Clean cultivation of a Valley Grove.

"Dooryard" trees are protected by buildings or litter. The forest seedling is protected by older plants and the mass of leaf-mold, twigs and so on found on the forest floor. Such conditions are not possible in orchard practices except by mulching and this in a very limited way. The "sod" apple orchards of the Northern states were, as a rule, well cultivated until of considerable age. Some California growers are practicing mulching the tree row, or a basin about the tree, to a limited extent, with hay, bean straw or alfalfa. The available supply of such material will prevent any large area being treated in this manner even if found desirable.

**Cultivation**—The cultivation of an orchard is usually divided into two operations. The first consists of breaking the orchard with a turning plow followed by the disk. The second consists of the future cultivations with shallow, small-toothed implements. The spring breaking or plowing should be done about blooming time.

A thorough discing or shallow breaking followed by an additional discing from the opposite direction from which the land was broken has been found very satisfactory. Deep rooted trees are highly desirable for several reasons. First, the roots are protected from heat and drouth, second, they are not so readily started into growth by a few warm days in winter, and third, a deeper root system tends to more completely utilize the tree's feeding area.

The future cultivation of the orchard may be done with the acme, spike-tooth harrow or some form of orchard cultivator. The latter are very satisfactory tools because of covering the ground quickly, thoroughly and at a small cost. Most types are built quite low so that they may be run close to the tree without injuring the branches or fruit. Their width is from seven to twelve feet.

The ideal cultivation is one that keeps a constant soil mulch upon the orchard until the end of the growing season. This means that the cultivator should be drawn over the field after each rain or irrigation, or with sufficient frequency to maintain the soil mulch if these do not occur. Orchards handled in this manner will seldom suffer for moisture.

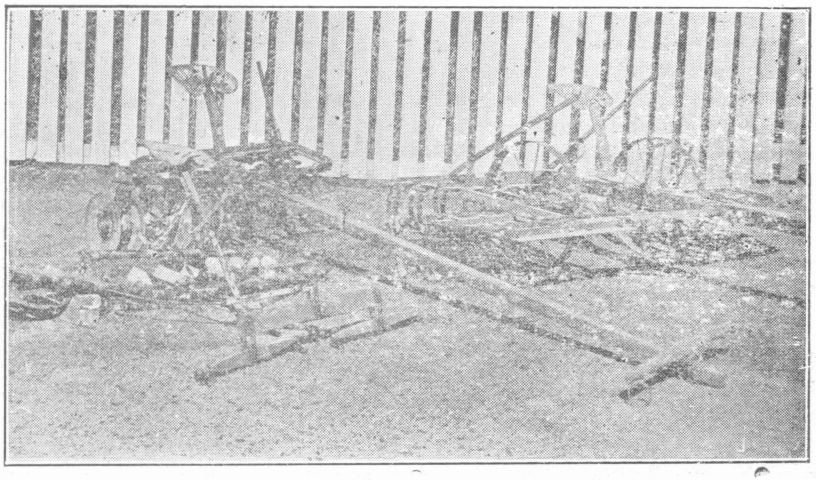

Fig. 12. Good orchard tools.

**Intercrops**—The ideal system of orchard tillage for Texas would consist of clean cultivation and a summer or winter cover crop. Very few growers, however, can afford this. It is necessary to have some returns from the land to help pay the expenses of bringing the orchard into bearing. The problem, then, is to select a crop that will bring the highest returns with the least detriment to the trees. What this crop will be must be determined by the individual grower but he should keep in mind

some of these general principles: (1) Give ample room for good tree cultivation. We have found that five feet on each side of young trees is not too much. (2) Short season crops as a rule, are less injurious than those occupying the land throughout the season (as cotton or sweet potatoes). (3) Avoid crops that require heavy winter cultivation and irrigation, thus exposing them to serious loss from freezing. (4) Plants known to be hosts to citrus pests should never be used.

Cotton should never be grown between the rows of a citrus orchard. It is bad practice as it does not form a windbreak and tends to take much moisture and nourishment from the soil. It is also likely to encourage the spread of root rot where there is any present in the soil.

**Cover Crops**—Cover crops, or green manures are essential in any system of orchard management. Where intercropping is followed, sufficient stubble may be left for this purpose but this is not often the case.

When to plant and what to plant is another matter for the individual grower. If winter money crops are grown between the rows a summer green manure crop will be used. This has the objection of using moisture at a time when the trees may need it the worst. On the other hand a heavy cover crop is frequently in the way during orchard heating operations in the winter. The legumes are favored by most of the California growers while some of the Florida growers look upon them with distrust, fearing they cause die back and other plant trouble. Of the legumes, Canada peas, cowpeas, the cover vetch and beans proved good at the Beeville Station. Cowpeas are an excellent summer crop and may be made profitable if good, pure varieties are used, only the seed pods harvested and the peas sold for seed. A crop of dry beans will also be found to be profitable. Of the non-legumes, oats and rye are frequently used. They are grown during the winter. All winter cover crops are said to retard growth in the spring by shading thus keeping the ground and roots cool. Where a system of cover crops is followed with either the old or young an additional amount of irrigation water must be supplied to maintain both the trees and the crop.

**Fertilizers**—With our present knowledge any attempt to recommend a fertilizer for Valley Citrus Growers would be mere guessing. It is not reasonable to suppose that any soil will endure cropping for a number of years without deterioration and the general practice is to restore in fertilizers the theoretical plant food removed by trees and crops. This practice has worked well in a few cases but in others it has either given no results or they have been negative. The form in which the various materials have been applied has also been studied without definite results.

So far as known there has been no systematic attempt to study citrus fertilizer needs in Texas. The Beeville Station started a project of this kind several years ago in which different sources and amounts of fertilizers were used but recurrent freezes without adequate frost protection made it necessary to give up the work. During the few years the work was continued without interruptions, no positive results were obtained.

Florida, California and several foreign countries have conducted fertilizer trials but none of these are of special interest to the Valley growers. However, since the California conditions are most similar to Texas, the following conclusions are given from a recent bulletin by Vaile.*

"Certain points of emphasis are consistently shown by each of these experiments:

1. There is a positive value to be derived from fertilizing citrus trees on any of the soils involved in these trials, as measured by increased crop yields.

2. This value seems to be associated primarily with the use of nitrogen.

3. No definite value can be attached to the use of potash or phosphoric acid in any of the trials reported, either when used in conjunction with nitrogen or when used alone.

4. Lime, applied as ground limestone, has not been of value in the trials reported except at Chula Vista on the Kimball sandy loam soil.

5. Bulky organic material has been of large importance in citrus fertilization.

6. Specific fertilizing materials have given different results in different locations; so much so that findings from one set of field trials should not be too literally interpreted for any other set of conditions.

7. Field trials with fruit trees are generally designed to measure the effect of contrasting systems of orchard management and cannot furnish exact answers to specific questions concerning the economy of any certain kind, amount, or method of application of fertilizer.

8. The field trials and orchard surveys reported upon in this publication indicate clearly that fertilization is required for the economical production of citrus fruits under usual southern California conditions. That the application of fertilizer is often delayed too long after the planting of an orchard, and that larger applications might be used with profit, are points that are also indicated.

9. Groves that have been allowed to deteriorate through lack of fertilizer may be greatly improved by the use of nitrogeneous fertilizer materials. Where deterioration is manifested by typical mottle leaf and attendant characteristics it appears that a correction of this particular trouble is not to be found in the use of commercial fertilizers, particularly in organic fertilizers.

10. Covering the ground with straw mulch, thus eliminating the necessity for any tillage operations, may be expected greatly to improve run-down citrus groves. This method of culture is likely to be limited in effectiveness to a period of two or three years, following which ordinary tillage should again be resorted to. This system of management is not well adapted to clay loam soils.

11. The use of winter green-manure crops has been followed by conflicting results in the different trials. In one case a marked increase in yield and an improvement in tree condition resulted; in a second case there was a slight decrease in yield; in a third case the results seemed to be

*R. S. Vaile, "Fertilizer Experiments with Citrus Trees." Calif. Agr. Expt. Sta. Bul. No. 345.

negative. The failure of the crop to always produce increased yields can apparently be accounted for in some cases, but has not been in other cases."

The conclusions are based upon many years of carefully conducted work and upon several soil types.

From the results obtained with fertilizers in Florida it seems they have made some progress for their particular conditions but since these soil conditions are so radically different from those of the Valley they are practically useless for us.

No doubt the newly established Experiment Station will undertake a study of this important subject as soon as practical. Until such time as definite results may be obtained, about the only recommendation that can be made is that of maintaining the soil humus and nitrogen by the use of green manure crops especially the clovers and stable manure.

**Irrigation**—The use of water has received some attention by the Texas Board of Water Engineers and Irrigation Engineers of the United States Department of Agriculture. At this time, however, we have not sufficient data to enable definite conclusions to be drawn. The general concensus of opinion is that most growers use too much water and too little cultivation and that the methods of application are not the most satisfactory.

As previously stated, a bearing citrus grove requires from thirty-five to forty inches of water per annum. The average annual Valley rainfall is about twenty inches. This rainfall is fairly well distributed, the most of it coming in the late summer and early fall when most needed. This leaves an average of from 15 to 20 inches to be supplied by irrigation. There are so many factors affecting soil moisture, however, that these figures can be only suggestive.

Some of the factors affecting the amount of water needed will be briefly mentioned in hope that they may help in the solution of the problem. (1) All plants transpire more rapidly in arid than humid areas. Owing to the nearness to the Gulf and the direction of the prevailing wind the relative humidity of most Valley points is high. This fact materially reduces the amount of water needed by the trees. (2) The amount and distribution of rainfall. (3) The character of the soil. Clays and loams are more rententive of moisture than the sands. (4) Temperature. (5) Wind velocity and its direction. The dry winds from the north and west will quickly cause injury to trees on a soil poorly supplied with water. (6) The age of the grove. (7) The character of the sub-soil. (8) Drainage. (9) Method of cultivating. (10) Character of intercropping.

**Method of Applying Water**—Irrigation water has been applied to citrus groves by the furrow system, basin system, flooding, sub-irrigation and the over-head (sprinkling) system. Of these methods the furrow system has given most satisfactory results upon loam soils, while a modified system of flooding or the basin system is most favored upon sandy soil. Whatever the system of application, each irrigation should be sufficient to thoroughly saturate the soil several feet deep. This object is usually

best attained in the furrow system by using short runs (not over 400 ft.) and a small head of water, permitting the flow to continue for several hours. The use of concrete flumes for distribution is highly desirable as it means a saving of water and the prevention of seepage.

**Time of Application**—The experienced grower can quickly determine the need of irrigation on his particular soil by observing the color and growth of the trees and by the appearance of the soil a few inches below the surface. Trees on the Beeville Station showed a need of water when a test showed the soil contained 6 per cent. moisture. Surface soil indications, however, cannot always be relied upon. It is frequently advisable to bore a hole in to the subsurface soil to fully ascertain the condition. In some cases an impervious layer of soil has formed several inches below the surface which prevents free percolation of the water. This may often be broken by a subsoil plow, in more serious cases dynamite has been used. Hardpan and plow-sole are said to be responsible for most non-bearing troubles.

Citrus trees suffer severe injury if allowed to become too dry. In all cases they should be watered before the leaves curl or fall. Most growers dislike winter irrigation but it should be done if the trees show signs of distress. Care should be taken to see that the grove has ample moisture just before blooming time. If allowed to become too dry before watering, a heavy dropping of fruit may result when moisture is applied.

Fig. 13. Tool used for opening furrows for irrigation.

**Drainage**—The history of most irrigated sections shows that sooner or later drainage becomes a factor of first consideration in crop production. Especially is this true in regions not naturally provided with good means of disposing of surplus water. From numerous letters, verbal reports, and personal observations it seems that the water table is slowly rising in some sections of the Valley and that steps should be taken at once to prevent further rise and resulting injury. In many sections good drainage may be provided by ditching into old river channels. In other cases it will be necessary to provide means of finally disposing of the water after it has been drained off of the farms by surface ditches or tile.

At the time drainage is provided for the soil water, consideration should be given to the surface run-off from heavy rains that occasionally visit the Valley with resulting crop loss. The formation of drainage districts is highly desirable but until such time as one may be properly organized much can be done by each farmer to drain his own land.

## PRUNING

Citrus trees in the Valley have, as a rule, received very little sysmatic pruning in spite of the fact that this is one of the most important operations in citrus culture. The properly pruned orchard in the Valley was the exception until the winter and spring of 1922-1923, when much of this work was started. This being the case, more pruning is needed than if the orchards had received some attention each year. It is especially important that newly planted trees be handled properly from the very beginning. This will obviate much work later as the trees grow.

### Object of Pruning

Pruning must not be considered a hit and miss job. There are certain well-defined principles to be kept continually in mind while doing this work. The primary object, and that underlying all pruning, is to develop a tree that will bear and hold a maximum crop of fruit. To produce the maximum crop, all the dead, decayed and injured wood must be removed. If this is left, a breeding place is provided for fungus diseases which are injurious to the tree.* All crossed limbs must be removed, as the injury caused by their rubbing together permits decay and weakened branches.

High-headed trees are expensive to spray and to harvest. Low-headed trees are more easily and efficiently sprayed, and are not likely to be so seriously damaged by high winds and are more of a protection to themselves against cold.

Limbs should not be allowed to hang low or drag on the ground as these make injury to the fruit easy and proper cultivation much more difficult.

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*Winston, J. R., "Commercial Control of Citrus Melanose." U. S. Dept. of Agr. Dept. Cir. 259.
Winston, J. R., "Commercial Control of Citrus Stem-end Rot." U. S. Dept. of Agr. Dept. Cir. 293.

Fig. 14. Young tree properly headed and pruned.

Many citrus trees in Texas have been allowed to grow into dense bushes in the center with all the fruit upon the outside. A well-shaped healthy tree should produce its fruit evenly distributed among the outer and inner branches. A tree that is too dense in the center is more favorable to the scale insects and diseases that prefer shade in which to develop.

Older trees should not be severely pruned all at once, but shaped up gradually by the removal of a few limbs at a time.

### Pruning at Planting Time

When the trees are moved from the nursery to the orchard with bare roots, all broken or injured roots should be removed with a clean cut. The tops should be cut back as soon as planted to overcome the effect of the heavy root pruning necessary in transplanting. The tops and root system should always be kept in balance.

Whips (i. e. trees with single unbranched stems) are headed back to a bud, 18 to 26 inches from the ground. After the branches start to grow, four or five well distributed about the upper 9 to 12 inches of the tree are left and all others removed as soon as they start.

Fig. 15. Tree headed too low.

Fig. 16. Tree headed too high

If balled stock is planted, remove all but 4 or 5 of the well formed and properly placed branches as the frame work for the top. The branches that are left should be cut back to spurs with two or three buds on each spur. When a tree is weak and frail to start growing readily, it should be more severely pruned.

Trees that are properly handled at planting time and carefully pruned for the next few years, seldom need much pruning after they reach bearing age.

In California, the trees are usually headed about 33 inches in height, and in Florida about 18 inches in height in the nursery row.

If this heading back has not been done in the nursery, it should be accomplished immediately after setting in the orchard.

### Pruning Older Trees..

If the trees were properly headed when planted, pruning, each succeeding year should be simply a continuation of the work started at that time. All undesirable branches should be removed when still small. Long weak, limbs that do not show tendency to branch out must be headed back to keep the tree strong, compact, well-shaped and with the greatest possible

amount of healthy, bearing wood. The top of a citrus tree should not be allowed to become too dense or thick in the center, nor should it be so open that the trunk and inside branches are likely to sunburn. (See fig. 17).

When a tree is filled with dead wood and badly formed limbs, these may be removed, and the exposed parts of the remaining branches and trunks painted with whitewash or Bordeaux paste to reflect the heat. Severe pruning of older trees usually results in a thick growth of water-sprouts and suckers. All these should be removed, except those needed for branches.

Fruiting branches can be distinguished from the suckers by their slow growth, smaller stems and leaves, and more frequent branching.

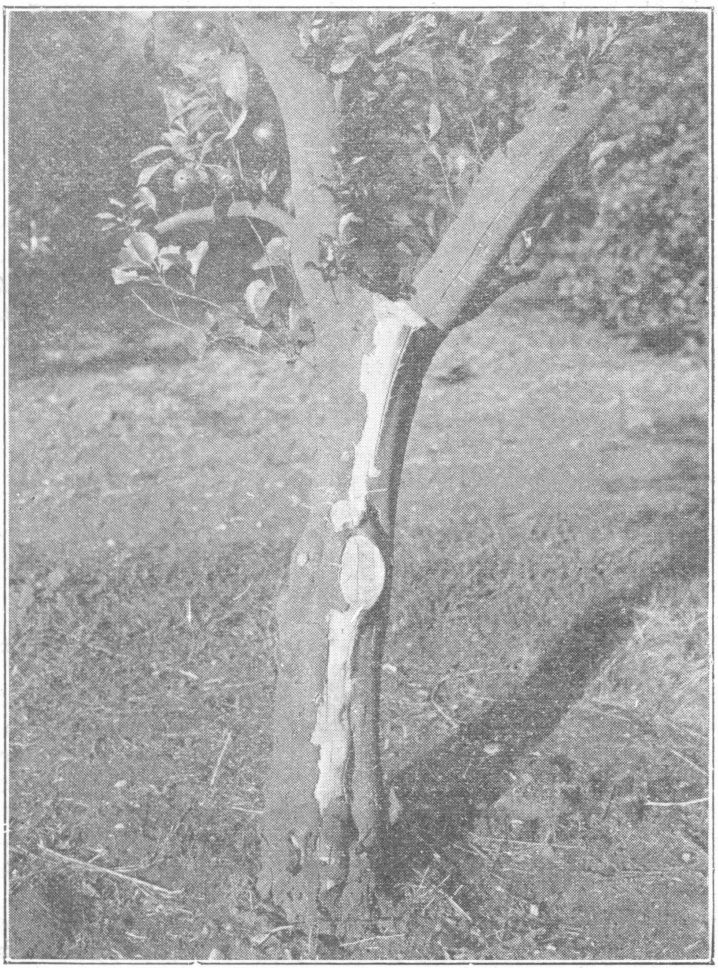

Fig. 17. Tree severely injured by sunburn.

Lemon trees are subject to a very vigorous, upright growth. To prevent this and to produce more branched wood, severe heading back is often practiced. The cut in every case should be just above a branch or bud on the outside of the limb. This bud or branch is then made the terminal bud or branch and will continue somewhat in the outward direction, opening the growth of the tree. Should the cut be made above an inside bud or branch, the tendency of growth will be more toward the middle.

The heading back process is, in time, to be followed by a thinning out of some of the branches that are forced out as a result of this treatment.

A good pruning saw, hand-clippers, shears and sharp knife should be a part of the equipment of every orchardist. Every cut should be made close to the trunk or limb that is left, and just above a bud or branch. Stubs will never heal over and are a favorite place for fungus and rot to develop, especially if not planted soon after the cut is made. Cuts, made close and clean with sharp tools, will heal over. Paint every cut the size of a quarter or larger, is a good rule to follow. White lead and linseed oil, a good quality of prepared white lead paint, shellac or liquid wax can be used as coverings. Most growers do not favor cresosote or tar preparations, for there is danger of injury.

Trees that have suffered from a freeze should be cut back to live, healthy wood. Work of this kind should not be done before the full extent of the injury can be readily seen. Numerous branches will develop on trees killed back by cold. All but a few desirable ones should be removed during the summer and those remaining pinched back as needed to properly shape the new tops and to cause hardening of this tender growth.

## SPRAYING AND DUSTING

No part of the Lower Valley is free from citrus insects and disease pests. Clean, bright fruit from healthy, vigorous trees will always find ready sale at top prices, while blemished fruit is hard to sell, commands a low price and is often an expense rather than a profit to the grower.

These pests can be controlled by proper pruning, cultural methods, spraying and dusting. Every orchard should be equipped with a spray from the very beginning. A small one (nothing smaller than a barrel pump) will do while the trees are young. Later, a power machine is a good investment.

Three fundamental principles underlie all spraying operations: (1) A proper machine is necessary, (i. e.) one that is capable of producing a pressure of 175 to 250 pounds. This will break the material into a fine mist, cover the fruit and foliage more thoroughly and reduce the amount of material needed per tree. (2) THE RIGHT MATERIAL AT THE RIGHT TIME. (3) Spraying must be done thoroughly. Every particle of leaf, both upper and lower sides, fruit and wood surface must be covered with the spray material.

Dusting is becoming more widespread each year and many growers are finding it to their advantage to possess a dusting machine in addition to a sprayer. It cannot, however, wholly replace the work of the spray machine. Dusting is done more quickly and with less labor expense

than spraying. It will efficiently control red spider, rust mite and thrips. Flowers of Sulphur may be used for the spiders and mites, and nicotine dust for thrips, or they may be used in combination for all three.

### Dusting for Rust Mites, Red Spiders and Thrips

Rust mites and red spiders are extremely sensitive to the fumes of sulphur. Three forms of sulphur are generally available.

**Flour of Sulphur**—This is coarse material, rather heavy and almost pure sulphur. It spreads well from the dusting machine and will completely kill the rust mites and red spiders if it is properly applied. This material is not bulky. Therefore, about twice the volume is required per tree to be as effective as Flowers of Sulphur.

**Flowers of Sulphur, or Sublimed Sulphur**—This is a very fine, fluffy material of great bulk and practically pure sulphur. It produces a fine cloud that will envelop the tree. Only about half the volume of this type of sulphur will be needed to accomplish the same results as would be obtained from the use of Flour of Sulphur.

**Sulphur and Lime Mixtures**—There are many of these mixtures on the market. Experiments show that lime has no determined effect on the rust mite and red spider and that sulphur will kill them. Consequently, a pure sulphur dust is to be recommended. Pure sulphur will not injure the trees, fruit or foliage, even when applied in excessive quantities.

**Time and Application**—It is not necessary for the sulphur to come in actual contact with the insects to effect a kill, but the closer the sulphur particles come, the quicker the insect succumbs to the fumes. Dusting may be done at any time during the day. It is not necessary to do the work in the early morning while the dew is on the foliage, although this is a good time to make the application. Sulphur applied in the heat of the day when the foliage is dry will stick until washed off by a drenching rain. The higher the temperature, the more rapid will be the oxidation of the sulphur. Consequently, effective results will be produced more

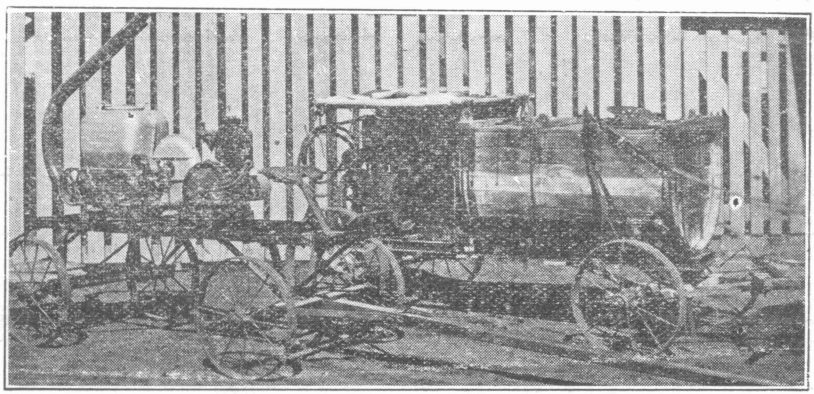

Fig. 18. A power duster and sprayer are needed by every citrus grower.

Fig. 19. High pressure means more effective spraying.

quickly during hot weather. Dusting in a temperature of 90 degrees Fahrenheit or above, should kill the rust mites and red spiders in a few minutes, while the same efficient dusting at a lower temperature would perhaps take days to effect a kill. When a rain occurs within two or three days after dusting, the sulphur should be applied again within a week.

Dusting for Thrips—Sulphur effectively controls the rust mite and red spider, but it will not kill the thrips. If thrips are present at the same time with the rust mites and red spiders, a combination dust may be used. There are several nicotine dusts on the market that may be mixed with the sulphur to control all three of these insects by the same application. If thrips are present at a time when it is not necessary to dust with sulphur for the other insects, nicotine dust may be used without the sulphur. (See spray schedule for liquid spray for thrips, rust mites and red spiders).

### Spraying Schedule for Citrus in the Rio Grande Valley

The following spray schedule contains all the applications that are usually necessary. By closely watching his trees, the grower can tell which of these applications to use and which to omit.

In order to standardize all citrus insect and disease control work in the Valley, the following recommendations for spraying were adopted at a meeting of representatives of the U. S. Department of Agriculture, Texas Experiment Station, Texas State Department of Agriculture, and the Extension Service, A. and M. College. This is the most reliable information obtainable and is adapted to Valley conditions. These recommendations will be revised from time to time, if new information becomes available.

Every grower should apply each year the three sprays given in heavy, black type, 1, 2, and 4. These are the necessary spray schedules. Sprays

Fig. 20. A power sprayer operating in a citrus grove.

numbered 3, 5, 6 and 7 should be used in addition to the others where there is need for them.

All water for spraying, except rain water should be softened. Three materials are commonly used for this purpose; Caustic soda, at the rate of 1 pound to 100 gallons of water and 3 to 6 pounds of soap. (2) Sal-soda 1 to 2 pounds to each 50 gallons of water. (3) One-half pound copper sulphate (blue-stone) and 1-2 pound lime to each 50 gallons of water.

**Directions for Using Soda and Soap:**—Dissolve the soda in 3 gallons of water and the soap in the same amount. Add to the full tank in this proportion.

**Directions for Using Copper Sulphate and Lime:**—Dissolve each separately in a little water and then pour into the tank of water with the agitator running. Then add the stock solution. This is especially adapted for use with oil emulsion sprays.

**Important:**

(TIME: BETWEEN DECEMBER 1ST AND FEBRUARY 1ST.
( WHEN TREES ARE NEAREST DORMANT. AFTER
( MOST OF THE FRUIT IS OFF AND BEFORE NEW
( GROWTH IS MADE.

1. (ENEMY: SCALE INSECTS. WHITE FLIES.
(MATERIAL: OIL EMULSION, 1½ GAL. to 100 GAL. WATER.
(N. B.—THIS IS ESSENTIAL ONLY WHERE SCALE OR WHITE
( FLY IS PRESENT. IT IS THE MOST EFFECTIVE
( SPRAY OF ALL IN CLEANING UP THE ORCHARD.

**Important:**

(TIME: WHEN TWO-THIRDS OF THE PETALS HAVE FALLEN.
(ENEMY: RUST MITES, THRIPS AND RED SPIDERS.
2. (MATERIAL: LIME SULPHUR SOLUTION, 3 QTS. AND 6½
( OZ. NICOTINE SULPHATE TO 50 GAL. WATER.

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(Time: 10 days or two weeks after No. 2.
(Enemy: Same as No. 2.
(Material: Same as No. 2.
( or
3. (If Citrus Scab is present—
(Time: 10 days or two weeks after No. 2.
(Enemy: Thrips and Scab.
(Material: 3-3-50 Bordeaux Mixture and 6½ oz. (or about a teacup-
( ful) nicotine sulphate to each 50 gallons of Bordeaux.
(N. B.—Nicotine sulphate may be omitted if thrips are not abundant.

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**Important:**

(TIME: WHEN FRUIT IS ABOUT 1 INCH IN DIAMETER.
(ENEMY: WHITE FLIES, SCALE INSECTS, RUST MITES, AND
( RED SPIDERS.
(MATERIAL: COMBINATON A or B. (SEE BELOW UNDER
( COMBINATIONS).
4. ( or
(IF SCALE IS **NOT** PRESENT—
(MATERIAL: LIME SULPHUR SOLUTION, 3 QTS. TO 50 GALS.
( WATER,
( or
(DUST WITH DRY SULPHUR.

---

(Time: Three to five weeks after No. 4.
(Enemy: Rust Mites and Red Spiders.
5. (Material: Lime sulphur solution, 3 qts. to 50 gals. water
( or
(Dust with Dry Sulphur.

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(Time: In July, if rust mites are abundant.
(Enemy: Same as No. 5.
(Material: Same as No. 5.
6. ( or,
(If scale is present—
(Material: COMBINATION A or B.

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(Time: About September 1st.
7. (Enemy: Scale insects, Rust Mites.
(Material: COMBINATION A or B.

DRY LIME SULPHUR: May be substituted for the Lime Sulphur Solution where desired, using 2 lbs of the Dry Lime Sulphur instead of 1 qt. of the Lime Sulphur solution.

DUSTING with dry sulphur, preferably flowers of sulphur, may be substituted for the Lime Sulphur where it is desired to combat only the rust mites and red spiders.

Frequently two or more types of pests occur at the same time. A combination spray may often be used to advantage. The following combinations have given very good results:

## A

### Soda Sulphur and Oil Emulsion Combination*

Soda Sulphur Solution, 1 gal. to 50 gals. of water to which is added oil emulsion at the rate of 3 qts. to 50 gals of solution.

The formula for making soda sulphur solution is found in Farmers' Bulletin No. 933, which may be had from the U. S. Department of Agriculture or the County Agent. Soda Sulphur is manufactured in a dry form and it may be cheaper than the solution. If it is desired to use this form of sulphur with the oil emulsion, add four (4) gallons of the solution to the 200 gallon spray tank, already nearly full of water. The dry form should be dissolved in a bucket of water before being added. Six or seven pounds of the latter should be used. The next step is to simply add the oil emulsion (3 gal. to 200) to the solution in the spray tank. This makes a combination that is highly satisfactory for killing rust mites, red spiders, scale insects and white fly.

## B

### Lime Sulphur Solution and Oil Emulsion Combination

The simple oil emulsions and lime sulphur solution will not mix. If simple oil emulsions are added to dilute lime sulphur solutions, the oil emulsion breaks down and free oil appears. If such a mixture is applied to citrus trees, damage will result.

If it is desired to use lime sulphur solution with the oil emulsions, it is necessary to use a binder, to make the respective sprays compatible. For this purpose, such materials as ground glue, milk powders, corn starch, laundry starch and flour are used.

**Directions:**—Dissolve a pound of glue or other binder in a gallon of water, either by heating or soaking and add three gallons of oil emulsion. Add three gallons of lime sulphur solution to about 195 gallons of water, and then add the glue-oil emulsion mixture. The resulting mixture is satisfactory for spraying if the precipitate consists of very fine particles which permeate the entire spray solution when the agitator is running. If the precipitate consists of large greasy masses adhering to the sides of the tank, it is not satisfactory and should not be used.

*Except where stated the directions for making these combinations are given on a basis of a 200 gallon tank. For a 100 gallon tank, divide all quantities by two. For a 50 gallon tank, divide all quantities by four.

Dry lime sulphur or barium tetrasulphide may be used instead of the lime sulphur solution. When so used, they should be used on the sulphur equivalent basis or so that the same amount of sulphur should be in the solution in the dilute material.

These combinations are satisfactory for rust mites, red spiders, scale insects and white flies. It is advisable that the growers proceed with considerable caution with this combination. It is fast gaining in favor with the Florida citrus growers, but it might do much damage if not properly made.

## C

### Bordeaux and Oil Emulsion Combination

Since there are diseases in citrus groves, spraying with fungicides may often be necessary to produce proper fruit. Bordeaux is undoubtedly the best fungicide known. It may also be necessary to spray for scales and white flies with the oil emulsions at about the same time that it is advisable to use the Bordeaux. The two may be combined and applied in a single application. To do this, make the Bordeaux in the regular way, either in the spray tank or in barrels. After it has been added to the spray tank, add the oil emulsion.

Oil emulsion may be used in this combination with satisfactory results. The Bordeaux retains it fungicidal properties and the oil emulsion its insecticidal qualities in the combination.

## D

### Lime Sulphur Solutions and Nicotine Sulphate

This combination is perfectly satisfactory and compatible. It makes a good spray for the rust mite and thrip. It is customary to use nicotine sulphate, 40 per cent. one quart to 200 gallons of water, to which is added 3 gallons of lime sulphur solution.

### Preparation of Materials Recommended in Spray Schedule

**Oil Emulsion (Cold Stirred)**—There are three kinds of stock oil emulsion. One combination known as "cold stirred" oil emulsion is made as follows:

| | |
|---|---|
| Whale oil soap | 8 lbs. |
| Paraffin oil | 2 gals. |
| Water | 1 gal. |

Place soap in the mixing vat. Add small quantity of oil and stir vigorously until no free oil remains. Continue to add the oil slowly, stirring all the time so that it will be completely emulsified. Then slowly add the water in the same way. This is the stock solution. For scale and white fly, it should be used at the rate of one gallon to 40 or 50 of **soft water.** Methods of softening water are given in the spray schedule. **All water in the Valley except rain water should be softened.**

**Oil Emulsion (Boiled)**—This formula was developed by Mr. W. W. Yothers of the U. S. Bureau of Entomology. In it, he has reduced the amount of soap necessary by using heat. The formula is:

Whale oil soap ..... 2 lbs.
Paraffin oil ..... 2 gals.
Water ..... 1 gal.

This combination must be heated to the boiling point and emulsified by forcing it two or three times through a hand pump. A hand spray, or barrel spray pump may be used for this purpose. This solution also requires the use of soft water. For spraying, dilute this stock solution, 1 gallon to 40 or 50 gallons of **soft water.**

**Commercial Oil Emulsion**—There are several brands of oil emulsion stock solution on the market that can be purchased already prepared except for the addition of the water. Soft water should be used for diluting these.

**Bordeaux Mixture**—

Copper sulphate (blue stone) ..... 3 lbs.
Stone lime ..... 3 lbs.
Water ..... 50 gals

Suspend the copper sulphate in a sack in a half barrel (25 gals.) of water until it is dissolved. Slack the lime and dilute to the same amount of water. Then pour these solutions together at the same time into another receptacle. Under no circumstances should the lime solution be poured into the blue stone vice-versa.

Bordeaux should never be mixed in iron or galvanized vessels. The blue-stone and lime solutions may be kept separately as long as desired, but the final mixture should be used the same day it is made, as it deteriorates rapidly.

Different formulas of Bordeaux Mixture such as 3-5-50, 4-4-50 or 3-4-50 may be made by simply changing the amounts of blue-stone and lime that are dissolved in the water and following the above directions.

There should always be an amount of lime equal to, or in excess of the amount of blue-stone used.

For combinations of oil emulsion, Bordeaux mixture, etc., see under spray schedule.

## Fumigation

Since 1887 fumigation in California has been used, until today it has become one of the chief ways of controlling insects injurious to the trees and fruit. The advantage of fumigation is that it controls scale insects with a minimum of labor in a very thorough and complete way. The chief difficulty has been to find the exact dosage which will give maximum results and at the same time not produce an injury to the tree. The cost of fumigating an average sized tree is about 25 to 30 cents. Fumigation may sometimes be necessary every season; if thoroughly done, however, it may be necessary only once in two or three years. Fumigation work is usually done by contractors who make a business of furnishing all materials and doing the work for a stipulated sum. Local associations often cooperate in purchasing and operating fumigation outfits.

**Treatment**—A mixture of sodium cyanide, sulphuric acid and water are mixed together to form the poisonous gas.

1½ ounces sodium cyanide.

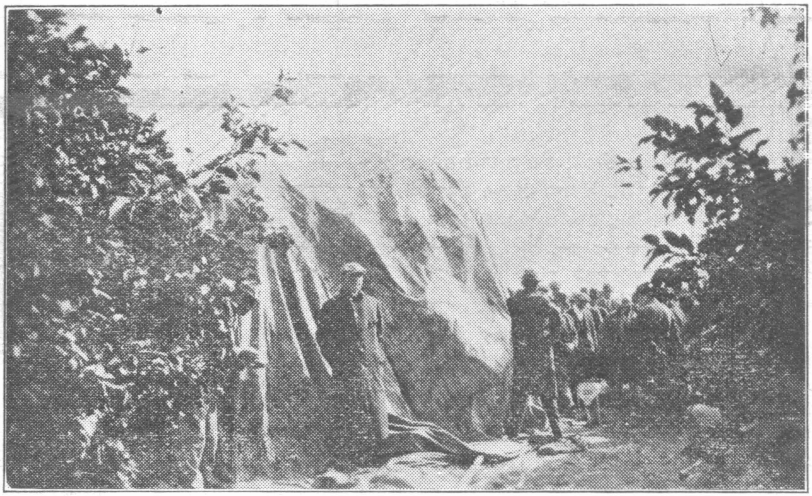

Fig. 21. Fumigating citrus under tent.

1 ounce (fluid ounce) sulphuric acid.
2 ounces water.

The water is first measured and placed in the generator, then the acid is poured in, and last when everything is ready for operation the cyanide is added.

Tents are spread over the trees that are to be fumigated and exposures of the tree to the gas is usually 45 minutes to an hour, depending upon the insect to be fumigated. Usually about thirty tents are operated by the crew doing the work and a new lot of 30 trees is treated each hour.

Recent inventions with fumigation machinery indicate that this practice will become more popular in the smaller groves, as the new machinery does not require the handling and mixing of the cyanide, acid, and other materials to generate the gas.

## WOUND DRESSINGS AND ANTISEPTICS

Pruning operations and the treatment of certain diseases on the trunks and roots of citrus trees are made much more effective by using the proper wound dressing and antiseptic wash. White lead paint or asphultom paint applied when the cut has been allowed to dry and then the paint coated over with shellac is a very satisfactory covering.

A wash of bordeaux paste is prepared by dissolving one pound of copper sulphate in one half gallon of water. Shake two pounds of fresh limestone in a gallon of water and pour the two solutions together, mixing thoroughly. This solution tends to kill all fungi or wounds and in treating diseased trunks or roots it gives good results.

Other wound washes that can be used in the place of bordeaux are carbolineum, bichloride of mercury (1-1000 water) and crude carbolic acid (1 pound laundry soap, 1 quart water, and one quart acid).

## INSECTS

No section of the Valley is entirely free from insect pests that devitalize the trees, blemish the fruit, reduce it in size and cause more rapid deterioration after picking. High quality fruit finds a ready and profitable market, while that injured by insects and disease is sold at a less profit and with more expense. Whole orchards may be found that have been practically killed by scale and others infested with several insects eral insects to such an extent that the fruit cannot be sold for the best price. Moreover, the general bearing ability of the trees is greatly lessened.

It is therefore essential that the grower recognize the different insects in order to apply the proper control measures. The description of the insects is given so that they may be identified without going into technical details.

**Purple Scale**—The female scales are long, often slightly curved and about 1-8 inch in length. The usual color is a purplish brown. The male is only about 1-16 inch long, winged and very narrow.

This is a very serious pest, attacking not only the fruit and leaves but all parts of the tree, often killing the smaller twigs, branches and entire trees if not controlled. It attacks orange, grapefruit and lemon.

**California Red Scale**—This scale is also circular in shape, but flatter and lighter in color than the Florida red scale. The female scales

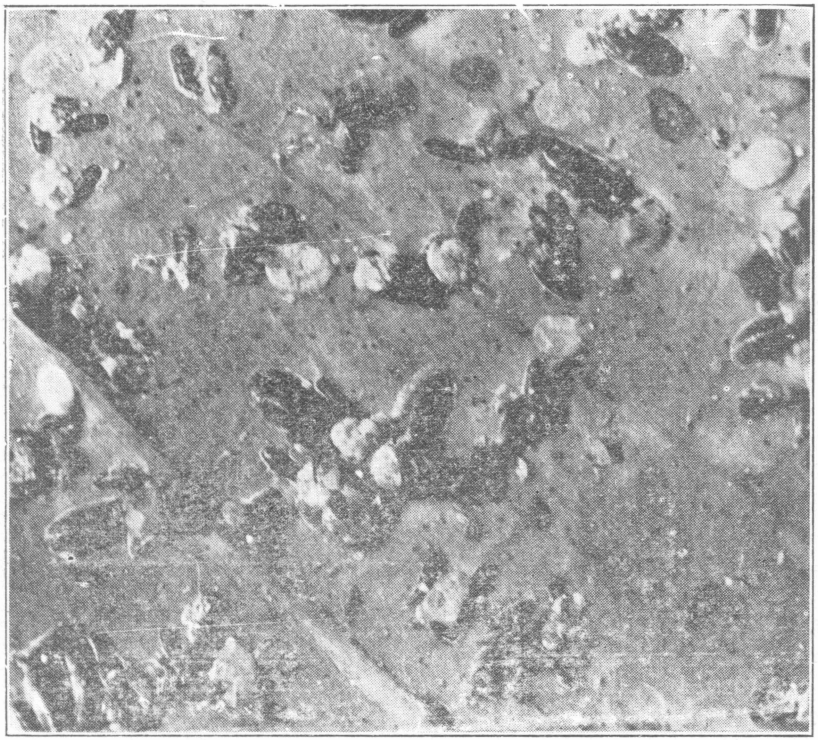

Fig. 22. Purple scale much enlarged.

are transparent, allowing the color of the body to show through giving it its distinctive coloring. The male scales are smaller, longer, and range from gray to dark brown in color. All parts of the tree including the trunk, limbs, leaves and fruit are attacked by this scale. The fruit is rendered unfit for market by the yellow spots that appear as a result of their injury. All citrus trees are subject to attack as also are Eucalyptus, palm and privet.

**Chaff Scale**—The female scales are irregular in shape, thin and brownish gray in color. Often they are found completely covering a leaf, branch, fruit or even the trunk of a tree so thickly that they appear like chaff blown into the tree in great quantities. The male scales are longer than they are wide and lighter gray in color. Several localities in the Valley have a rather serious infestation of this scale, and almost all sections are at least lightly infested. The scale is smaller than the purple scale, but fully as destructive. It greatly reduces the vitality of the tree and causes the leaves to turn yellow and the fruit to drop off. It attacks lemon, orange and grapefruit especially. A few other varieties of trees are also susceptible.

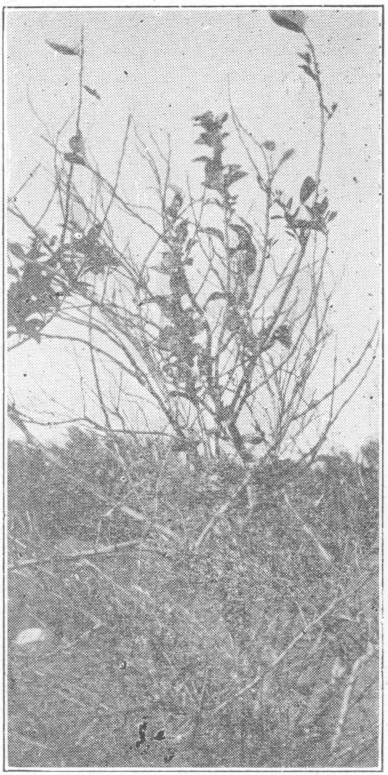

Fig. 23. Tree severely injured by Purple scale.

**Florida Red Scale**—As its name indicates, this scale is dark reddish brown in color and is characterized by its exceedingly regular, circular form. It is slightly larger and darker than the California red scale and has a lighter brown center that is nipple shaped. This scale will usually be found in large colonies on the fruit and leaves, causing them to turn yellow. Orange, lemon, grapefruit, oleander and the date palm are subject to its attack.

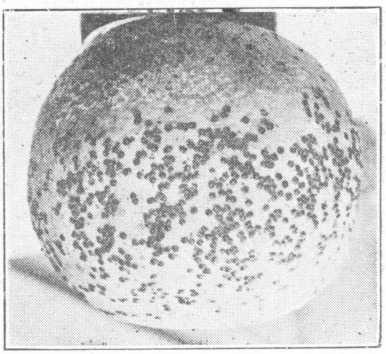

Fig. 24. Florida red scale.

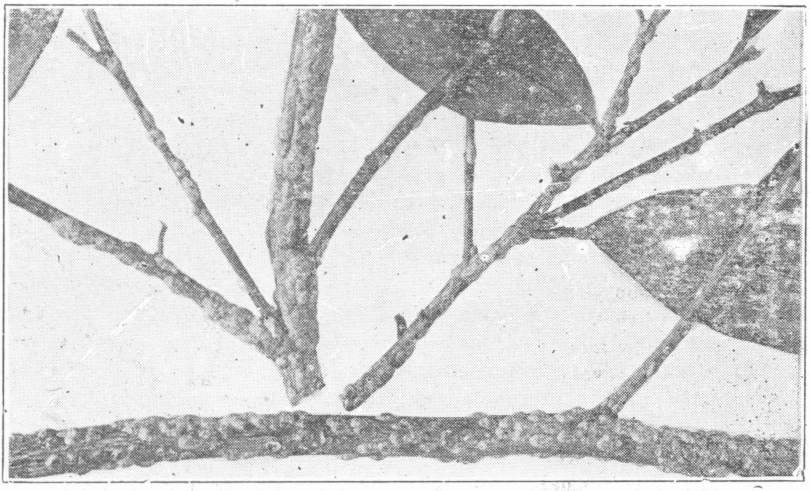

Fig. 25. Chaff scale on orange leaf.

**Soft Scale**—This scale is not as widespread as the other scales, although it has been reported from almost every part of the citrus belt. It may appear for a time in little colonies usually on the small twigs and leaves. It can be easily distinguished from the other scales by its large size and soft covering. The color is light brown with a few dark markings on the old ones. The males are long and slender and a lighter brown than the females. The females work principally along the mid-

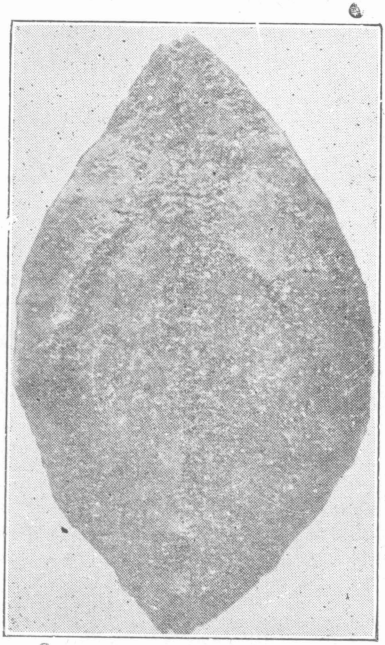

Fig. 26. Chaff Scale on grapefruit.

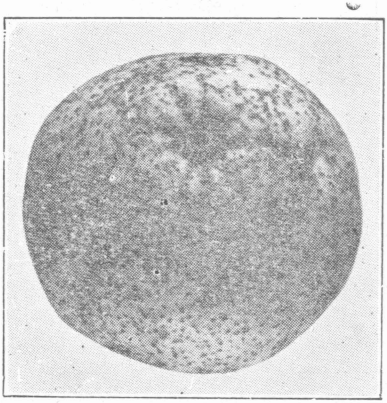

Fig. 27. Soft scale.

ribs of the leaves and on the smaller branches. This scale is usually

more numerous on the younger trees, differing in this respect from the other scales. A very large number of hosts to this scale are found in the Valley.

**Sooty Fungus**—Soft scale, white fly, plant lice and others put out a sweet, sticky secretion that covers the leaves and sometimes the fruit. Upon this secretion, called honey-dew, a fungus grows, giving it a black, sooty appearance. This sooty fungus does little direct injury to the leaf or fruit, but gives it a very unattractive appearance. Controlling these pests will prevent honey-dew and the sooty fungus.

**White Fly**—There are several species of this insect, but the general appearance is much the same. The adult is a small white insect about 1-16 inch long. It rests on the under side of the leaf and flies out in numbers when the foliage is disturbed. It lays a very small egg on the stem, from which hatches a small larva that crawls about for a few hours. It then inserts its beak into the leaf tissue and remains stationary for three of four weeks, sucking the leaf juice for food. It then changes to the pupa or resting stage, which occupies about two weeks during the season but continuing over winter for the last broods.

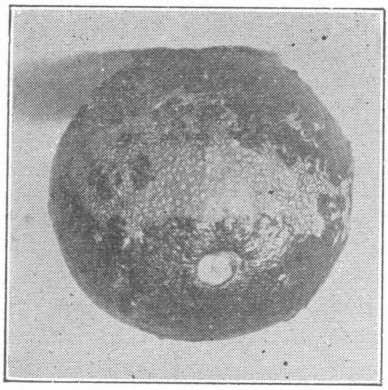

Fig. 28. Fruit showing injury from thrip

Two kinds of damage result from an infestation of white fly. When they are present in large numbers, feeding on the sap, the tree is materially weakened. They also produce a honey-dew that drops on the leaves and fruit, furnishing a medium for the development of sooty mold. This mold prevents even ripening of the fruit and otherwise damages the marketable qualities.

White fly attacks all citrus trees and about thirty other species of trees and shrubs, among the most common of which are china berry, cape jasmine, privet and persimmon.

Scales and white fly can be controlled by the use of oil emulsion sprays. (See spray schedule.)

**Citrus Thrips**—The adult thrips are very small and can scarcely be seen without the use of a glass. They are orange or yellow in color and move quickly over the blossoms or fruit, often appearing in the blossoms as a little speck or pollen. They are less than 1-30 inch in length and very slender. Thrips become especially abundant about the time the trees are in full bloom and begin to work as soon as the petals fall, continuing through the summer.

Unless a careful investigation is made during the blossoming period, the presence of these insects is usually first noticed by the scars on the young fruit. The injury makes a leathery ring about the stem and other well-defined scars on other parts of the fruit. This blemish causes the fruit to be thrown into a lower grade.

Thrips often start to work on the young trees in a nursery. While the trees are very young, they may be quite severly injured by the attack of the thrips on the leaves and buds, giving them a distorted appearance and retarding their growth. Thrips may be found on all citrus trees, also on pomegranate, pepper, willow, umbrella trees and rose bushes.

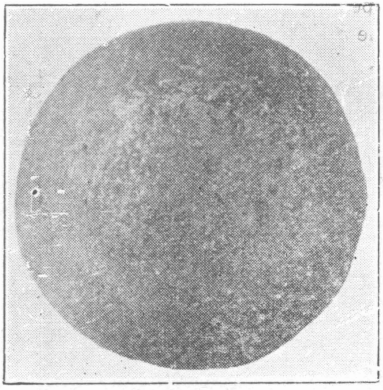

Fig. 29. Fruit showing injury from rust mite.

Since this insect gets its food from under the surface of the plant tissue, a contact insecticide must be used to control them. A forty per cent. nicotine solution is used either by itself or in combination with other sprays. See directions under spraying. Dusting with nicotine dust may be used instead of the spray.

**Citrus Rust Mite**—The adults of this insect are so small that they cannot be seen with the naked eye. They are a bright yellow in color, long and somewhat wedge shaped when seen under a lens. Of all the insects affecting citrus in the Valley, this one is the most widespread. It occurs in great numbers on the leaves and fruit and during the warm weather, it multiplies very rapidly. It is usually the appearance of the leaves or fruit that gives the grower the first indication of their presence. On the leaves they make dark spots and lessen the color. The injury is not noticeable on the fruit. The mites feed upon the oil of the rind. The rind, after injury, becomes a distinctive russet color on oranges and a silvery russet on lemons. Fruit attacked by the mite does not develop fully and remains undersize.

This insect can be controlled by lime-sulphur sprays or by dusting with dry sulphur. (See spray schedule).

**Citrus Red Spider**—The adult insects are bright red in color and about the size of a pin point. In serious infestations, they may occur so thickly that they give the foliage and fruit a reddish color. They work on lemon, orange and grapefruit. Their injury is characterized by a lighter, mottled coloring of the leaves and sometimes of the fruit. By injuring the leaves, they prevent them from functioning properly, decreasing the vitality of the tree and often causing the fruit to drop before maturity. Control same as citrus rust mite.

**Citrus Mealy Bug**—The bodies of the adult females are a light brown to yellow color and are completely covered with a thick waxy covering. They may cause considerable damage to citrus trees as they attack the bark, roots, fruit and foliage. They will be noticed in clusters on the different parts of the tree. On account of the honey-dew that is secreted, ants are usually to be found in large numbers near these bugs. The

ants are responsible for spreading them from one place to another. This insect feeds on a great variety of hosts. There are many natural enemies of these bugs that help to keep them under control. They are not serious pests in the Valley. Should they appear in large numbers, they can be controlled by the oil emulsion, or nicotine dust, or by the spray recommended for thrips.

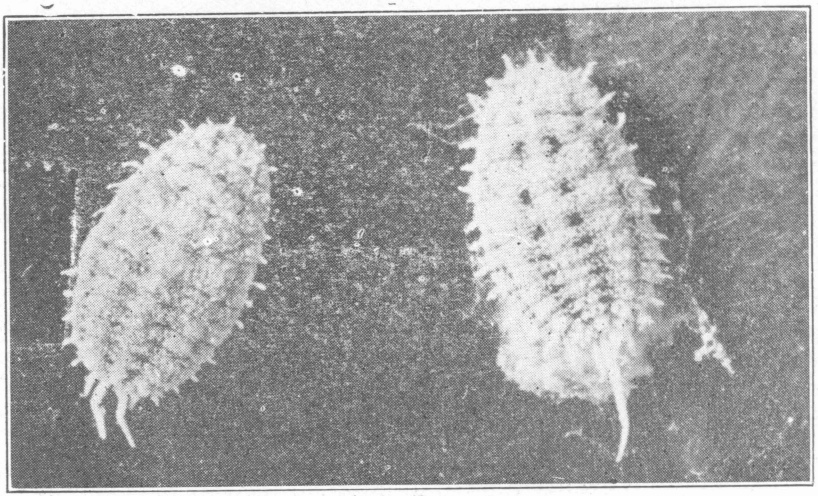

Fig. 30. Citrus mealy bug (enlarged).

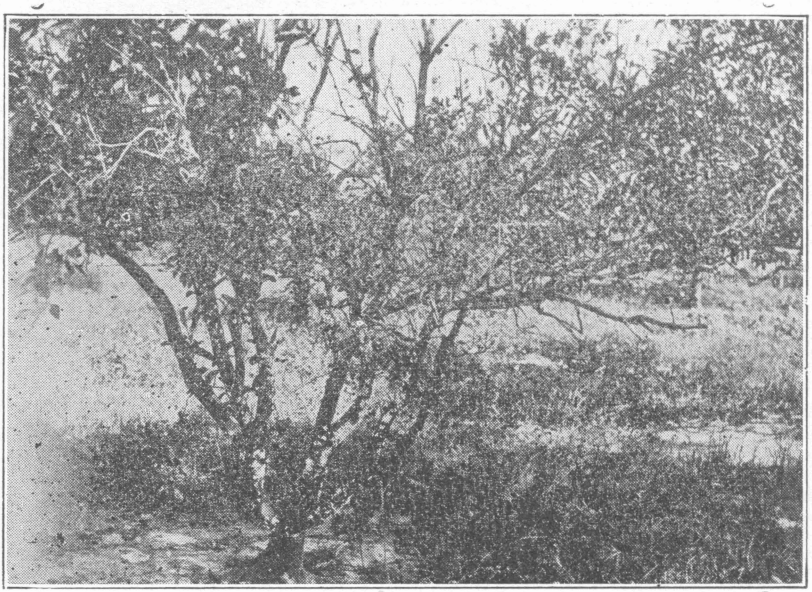

Fig. 31. Tree severely injured by cottony cushion scale.

**Cottony Cushion Scale**—The adult scales can be readily identified by the yellowish or reddish brown bodies, to which are attached large, whitish, ribbed, cottony masses of eggs. The eggs are deposited inside the masses of cottony secretion and are bright red in color.

This scale reproduces very rapidly and will attack the foliage and branches of the tree so intensely that it will be weakened and consequently killed unless control methods are applied. This insect will at-

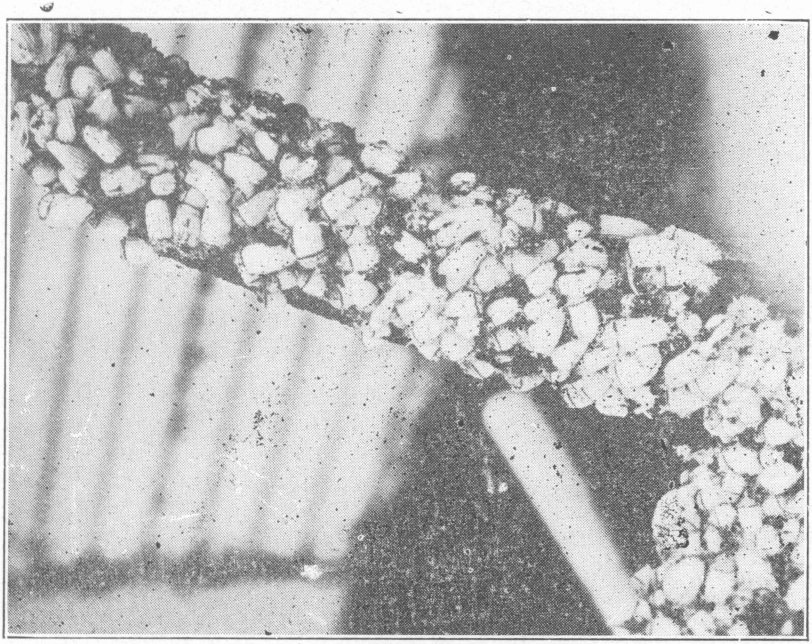

Fig. 32. Cottony cushion scale.

tack all citrus trees and many other trees. It has been found only in small colonies in the Valley and the introduction of the "Vedalia" lady beetle has held them in check. These lady beetles can be obtained through the Department of Agriculture at Austin, Texas. This scale cannot be controlled by the usual sprays recommended for controlling other scale insects, because of its waterproof covering. It is not a serious pest at the present time.

**Orange Dog**—This large, ugly, foul smelling worm is the larva of a very pretty butterfly. It is found at times feeding on the foliage and the tender shoots of the citrus trees. They usually appear singly or in small numbers but they are voracious feeders. Their ability to eat a

great deal sometimes makes control measures necessary. Since they are easily seen and few in number, hand-picking is the best control measure. Arsenate of lead, 2 pounds to 50 gallons of water sprayed on the trees, will also effectively control them. Calcium arsenate or arsenate of lead may be dusted on in dry form with good results. It is advisable to mix these dry forms with the same amount of lime.

**Flannel Moth**—The larvae of this moth are small hairy worms. The hairs are very irritating to tender skin. They do not often occur in numbers large enough to necessitate control measures. In case control measures seem advisable, spray or dust as directed under orange dog.

**Ants**—The small red or fire ant is the principle pest of the young citrus trees. It burrows about the crown of the trees and great care must be used in treating the nests to avoid injury to the trees.

Control—Calcium cyanide in the dust form when dusted into the disturbed nests with a dust blower gives satisfactory results. The young orchard should be inspected every week during the ant season and repetition treatments given where a complete kill was not secured with the first application.

**Termites or White Ants****—In some instances, these insects are quite troublesome to growers where twigs or stumps have been allowed to remain in the orchard. If new land is well cleared and worked to other crops for a year or two before planting the orchard, this pest will be of little consequence, unless piles or stumps, or wood are left continually near the trees. Where this insect is doing damage, the nests should be located and control measures applied as directed under ants. Termites will not tolerate light. If injury is being done to roots of citrus trees, clear away the soil and leave the roots exposed for a few weeks. Clearing away piles of wood, left in the orchard for fires, will often expose these termites to the light and drive them away.

### Beneficial Insects

**Ladybird Beetles**—There are several species of beneficial insects that help the farmer with his fight against the injurious pests. They are a big factor in insect control. Among them, the ladybird beetles are most striking. They have often been mistaken by growers for injurious insects.

These little beetles feed on the young of some of the injurious insects and by reducing the number of these, prove their friendship for the farmer. The larva is a peculiar looking creature, resemblying a lizard in shape. It is about one-fourth inch long. It changes from this form to the adult beetle by molting. The most common and beneficial ladybird beetle is a black one, with one red spot on each wing. It is known as the twice-stabbed ladybird beetle.

**These are not true ants. The name "wood-lice" is also applied to them.

## DISEASES

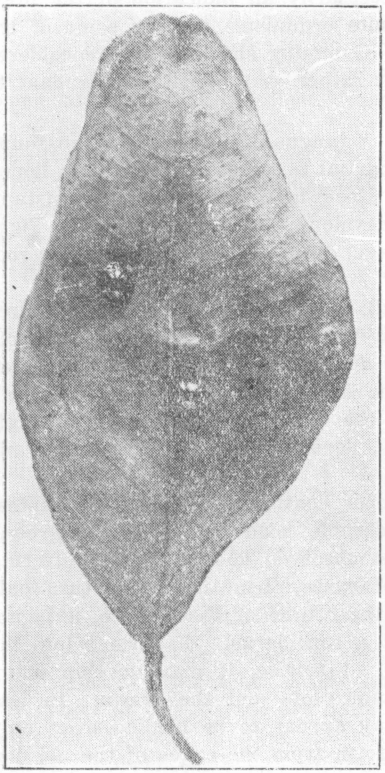

Fig. 33. The ladybird beetle. One of the orchardist's friends.

The diseases of citrus are of two kinds, those caused by parasitic bacteria or fungi and those resulting from mechanical or physiological disturbances. The former may be controlled by spraying, the latter usually by cultural methods.

**Citrus Scab**—Citrus scab is common in the Valley, especially on sour orange, though it may be found on grapefruit, lemon, limes

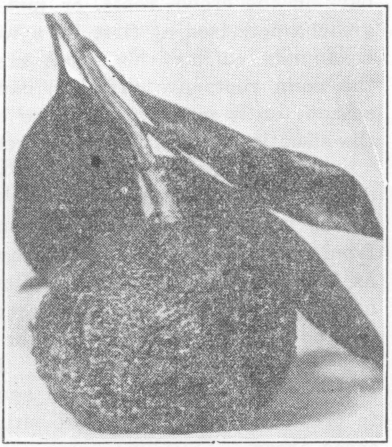

Fig. 34. Citrus scab.

and tangerines. It is particularly bad on young sour orange seedlings. Scab is caused by a fungus that attacks the leaves, twigs and fruit. Observation tends to show that the sweet orange is more resistant to the disease than the other varieties of citrus. Scab is first noticed as light brown, rough, raised, surface spots. As the disease progresses, these spots enlarge and may run together, making an irregular, warty surface. Frequently, as a result of severe infection, the leaves are crumpled, mis-shapen and may die prematurely. Young fruit, when attacked by scab, will become warty and unfit for market. This disease is especially bad on nursery stock where it attacks leaves and young twigs.

**Control**—Two methods of control are recommended. (1) Cut out all infected twigs and fruit, which should be destroyed by fire. Diseased shoots of sour orange and lemon in an orchard are a continual source of infection and should be carefully looked after. (2) Bordeaux mixture, 3-4-50 may control this disease if it is applied at the proper time. (See chapter on spraying). In nurseries, it may be necessary to make

several applications of Bordeaux Mixture before the disease is held in check.

**GUM DISEASES**—A disturbed physical condition of the tree, as well as certain diseases, cause exudation of gum. While gumming indicates that something is wrong, it is not necessarily an indication of the presence of a specific disease. The definite organisms causing some of the citrus diseases are still unidentified. Gumming should not be considered a definite symptom of any disease, but rather as a condition attendant to that disease.

**Foot Rot or Mal-di-goma**—This is a fungus disease more often found in low, moist, shady locations. It is partial to sweet orange, rough lemon and grapefruit stock. Sour orange stock is considered very resistant. Several factors are favorable to the development of this disease: Tight soil, excessive moisture and poor drainage, deep planting and improper root stock.

Foot rot usually begins as a small spot or spots of decayed, soured bark in the crown roots, or just below the ground surface. These spots are characterized at first by a watery appearance, under which gum may be found. From this small area, the disease rapidly spreads until all the main roots are affected, causing the death of the tree in a single season; or it may spread more slowly, depending on the root stock and the situation of the individual tree.

This disease yields readily to proper control measures, the greatest danger being that it may gain considerable headway under the ground before any indication of the trouble is observed above. Trees suffering from foot rot have an unhealthy appearance, then the leaves turn pale as if suffering from drouth. During the course of the disease, it is not uncommon for foot rot to spread for a considerable distance below the ground on only one side of the tree. Likewise, it may develop many scattered diseased areas along the main roots and the crown. In less severe infections the diseased spots may appear to be healing over, only to break out again in a more virulent form from the edges of the old diseased areas.

**Control**—The use of sour orange root stock is doubtless the best method of prevention. As the growers insist more and more on good sour orange stock, the loss from foot rot will be greatly lessened.

All diseased spots should be carefully located and cut out to clean healthy wood, and a good antiseptic applied to the wounds. Paint all the exposed roots and the trunk with the same antiseptic to prevent further spread of the disease. Leave the crown roots exposed for some time and stir the ground as often and as thoroughly as possible during warm, dry weather. Above all things, keep continual watch of the groves where the disease has been found and do not relax vigilance after applying the treatment. Examine the treated trees at short intervals to make sure that the disease has been killed.

**Gummosis**—This disease is found in all sections of the Valley. It is an infection of the bark, the disease showing principally on the trunk and the larger limbs of bearing trees. It seldom attacks very young trees. All varieties of citrus are subject to it. Gumming, although resembling

gummosis may be induced by several causes. Gumming may be caused by a fungus or it may accompany attacks of foot rot. Likewise, gum exudation frequen ly follows wither-tip and scaly bark. Mechanical injuries such as wind, hail, twisted and cracked limbs will also cause a tree to gum.

Gummosis may be recognized by the diseased areas or spots of dying bark. These spots appear rough and scaly, and the dead or diseased tissues become saturated with gum which later hardens. The dead bark is forced up and breaks into scales and strips as new growth takes place beneath. These flakes and strips fall off, leaving a scar with irregular surface and outline which gives a healed appearance to the wounds. Later, this same area will again become diseased and new gum will flow as in the previous year.

**Control**—The specific cause of Gummosis has not been determined. The treatment of the disease is a simple operation, but requires perseverance and thoroughness. All dead and diseased bark must be cut back to live, healthy tissue. **Do not leave a particle of diseased tissue.** The cuts should be made clean with a sharp knife, as a cut of this kind will heal more quickly than one with a ragged outline. Some antiseptic should then be used to cover the wound. A paint made of Bordeaux paste is most widely used with good results. A wash made of commercial or a self-boiled lime-sulphur may be substituted for the Bordeaux paste. Either one of these stock lime-sulphur washes testing 32 degrees Baume' should be diluted at the rate of one part to 12 or 15 parts of water.

Where Gummosis is prevalent, it is advisable to paint the trunks of both affected and healthy trees with an antiseptic wash.

**Scaly Bark**—This disease is confined principally to the sweet orange. Gumming occurs in patches on the trunks and branches of the trees. The early stages of this disease are quite distinct. The spots are small, round, reddish to brownish in color and raised above the healthy wood. These spots may appear as though saturated with oil or water. As the disease becomes older, the bark on these spots becomes stiff and cracks, later breaking into small scales. The spots may be separate or run together into large areas with a scaly appearance. This stage much resembles gummosis. Scaly bark will appear on all parts of the tree but rarely on small twigs. It develops very slowly. The injury to the leaves is not important.

**Nail-Head Rust**—The same fungus that causes scaly bark is also the cause of the injury to fruit known as nail-head rust. The disease starts first on the green fruit in small sunken rings that are yellow to brown in color. The center of the ring is raised above the sides. As it progresses, the rings sink in the center and the color becomes darker. **Scaly bark and nail-head rust are not known to be in the Valley at the present time, 1924.** A disease called scaly twig rupture by the State Department of Agriculture has been found in several places and may be mistaken for scaly bark. The above description of these diseases is given so the grower can be on the watch for them.

**Scaly Twig Rupture**—The following quotation from the State Department of Agriculture bulletin (No. 75) describes scaly twig rupture: "This disease is a new trouble of unknown cause, which has lately been found in several locations in the Valley. Recent observations indicate that the trouble is one of physiological origin, but work is being carried on to determine definitely the cause. The trouble resembles Florida Scaly Bark more than any other disease reported from other states, but differs from it in several particulars. Florida Scaly Bark does not attack grapefruit readily, while Scaly Twig Rupture occurs more commonly on this class of citrus than any other.

"The disease is first noted by a brownish discoloration on the twigs which enlarges and becomes raised. A comparatively distinct line of demarcation separates the healthy tissue from the discolored areas. Such areas differ from die-back discolorations in being more distinct and pronounced. The raised brown spots later crack, forming cankerous lesions.

**Control**—"No specific means of control can be given until the cause of the trouble is worked out. In the meantime, badly infected trees should be removed. Trees to be treated should be freed of all scales and other insects and should be properly pruned so as to remove the greater part of the affected tissue." The State Department of Agriculture recommends spraying with Bordeaux Mixture as given under scab.

**Root Rot**—Rotting of the roots and rootlets may result from the attack of a fungus in the ground or from mechanical injury. Trees planted too deeply in the ground may develop this trouble. In many instances, root rot can be attributed to such factors as poor drainage, deep planting, and tight soil. On the other hand, it may result from a root rot fungus that lives in the soil. When the effects are noticed externally, trees affected with this trouble are usually in too bad a condition to warrant remedial measure.

**Control**—All infected trees should be removed and burned. Conditions that might have caused this trouble should be studied and corrected. All roots and stumps of affected trees should be removed, the holes should be left open for some time and the soil well aerated before replanting.

**Citrus Canker**—This disease is the most destructive of all citrus diseases known today. Due to the prompt and efficient work of the Federal Government and the State Department of Agriculture, this disease has been well controlled in Texas. It is doubtful if there are any known infections in the State at the present time. Strict inspection and eradication have cleared the orchards of this menace and quarantine laws and inspection should prevent it from again gaining a foothold. Much depends on the co-operation of the growers themselves. Should this disease be suspected, send a sample of it to the State Department of Agriculture, Austin, Texas, immediately for identification. Prompt action in this regard may prevent serious loss.

Melanose*—This disease seems to take several forms. The common form of rusty melanose is not now widely prevalent in the Valley. Recently, however, several infections have been found and it may in the fu-

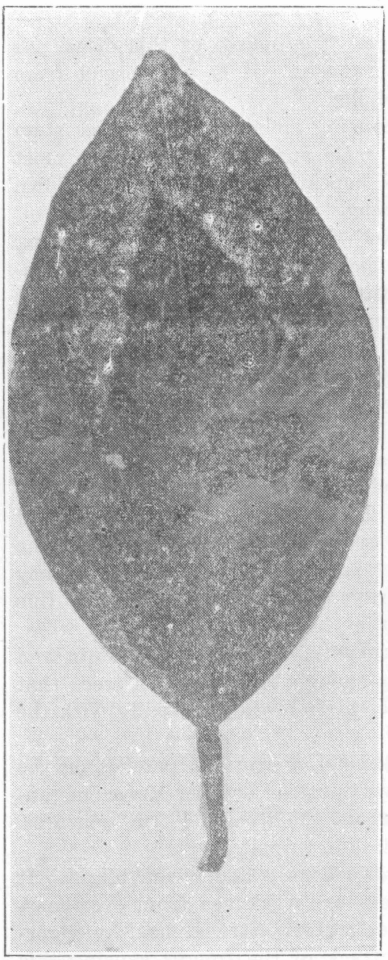

Fig. 35. Citrus canker.

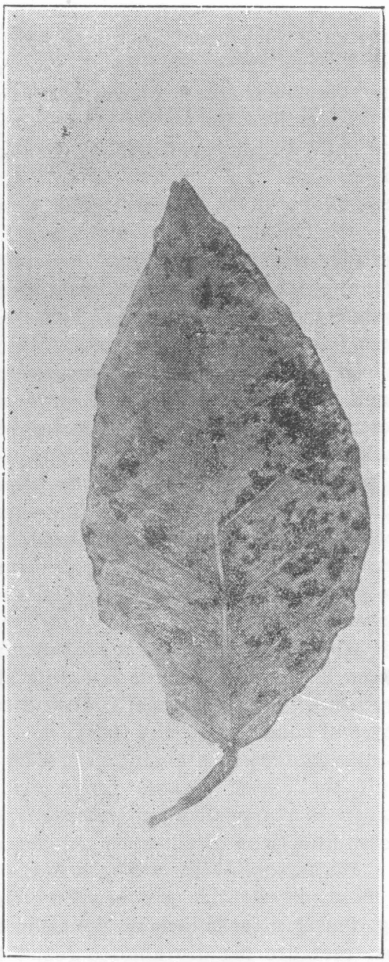

Fig. 36. Leaf showing Greasy Melanose.

ture become a serious problem. Freedom from this disease may be due, in part, to the fact that the orchards are young.

Melanose is a disease of the foliage, fruit and young twigs. It is caused by a fungus found in the dead wood of citrus trees where it propagates. It may be expected to be most serious in orchards where proper pruning has not been practiced. When dead bark containing the fruiting bodies of this fungus, is wet, it frees small strings of the spores that wash down over the fruit and tender foliage. If sufficient moisture is present, these strings of spores germinate and kill an area of the surface cells which later turn brown in color and become hardened. As the leaf or fruit tissue grows this mass of dead cells is raised above the rest of the surface

causing a rough and unsightly appearance. The source of this disease is the fungus spores formed in the dead branches. It is not spread from the affected surfaces of the fruit and foliage.

**Stem End Rot***—The same fungus causing melanose also causes stem end rot. Fruits weakened by attacks of scale and other insects are most susceptible. The growth of this fungus beneath the calyx breaks down the interior of the fruit causing rapid decay.

**Control of Melanose and Stem End Rot**—Thorough cleaning out during the winter of all dead limbs and twigs which may harbor this fungus, together with spraying for scale and white fly, are considered the best control measures. All wood removed from the trees should be burned or buried to destroy the fungus.

**Black or Greasy Melanose**—Another type of melanose known as black or greasy melanose is quite widely distributed in the Valley. The exact fungus causing it is unknown. It is recognized by the mottled, dark, greasy blotches on the fruit, leaves and tender twigs. This fungus is probably carried over in the dead and decaying wood and spreads to other parts of the tree from this source. This disease may be found at all seasons of the year, but it is usually at its worst during the spring. The same control measures as given for melanose apply to black or greasy melanose. Trees properly pruned and sprayed are seldom affected by this disease.

**Anthracnose**—A fungus causes anthracnose, withertip, tear stain and bloom blight, but since it is rarely strong enough to develop on trees that are healthy and vigorous, control measures have to do principally with the physical condition of the trees.

Anthracnose is characterized by dark colored spots or patches on the fruit that later decays, rendering it worthless. Another form of anthracnose starts in small reddish spots about the time the fruit matures. These infections often cause considerable loss in transit.

**Withertip**—Withertip is a stage of anthracnose and bloom blight. It is most prevalent in groves where the trees are weakened from over-bearing, insect attack, lack of nourishment, or water. Strong, healthy vigorous trees are usually able to resist the attack of the fungus causing this disease.

Common symptoms of this disease are dead twigs, yellowing and shedding of leaves and early dropping of fruit.

**Tear Stain**—The fungus causing anthracnose and withertip may cause superficial spotting of the fruit at any time after it is half grown. This condition does not injure the quality of the fruit, but reduces its value on the market.

**Bloom Blight**—Another indication of the presence of the fungus causing withertip and anthracnose is the blighting of the blooms. The tree may shed many of the blooms prematurely.

**Control**—Since withertip and these other related diseases are caused by a fungus that is not strong enough to do serious damage to healthy

*Stevens, H. E., "Florida Citrus Diseases," Fla. Expt. Sta. Bul. No. 150 1918.

vigorous trees, the control obviously lies in efforts to produce a thrifty growth. Pruning to remove all diseased twigs is of prime importance, as the fungus lives over from one season to another in them. All cuts should be made well back of the diseased parts and into the healthy tissue. If withertip is controlled by pruning and by stimulating the tree to a more healthy condition, anthracnose and bloom blight need not be feared.

## PHYSIOLOGICAL TROUBLES

**Dieback**—Dieback is more of an abnormal physiological condition than a disease. It is usually attributed to such factors as malnutrition, poor drainage, improper fertilization, and soil conditions. It is thought that dieback may be brought on by an over supply of organic matter in the soil. This seems to stimulate the growth of the tree and cause characteristic symptoms of dieback such as gum pockets, cracked fruit, ammoniated fruit, bark excrescences, multiple buds and stained terminal branches. These conditions are not found in the more mature wood, but rather on long, immature distorted branches resuting from abnormal growth.

Dead twigs may be a sympton of dieback, but this is more often a definite indication of withertip.

**Control**—Each case of dieback must be considered individually and an effort made to find the contributing causes.

So many and so varied are the causes of dieback that general directions for control would be misleading and possibly result in misspent effort. In case dieback is suspected, consult your county agent or the A. and M. College for advice in handling your particular problem.

**Frenching, Mottled Leaf or Chlorosis**—This trouble is readily detected by the mottled marking or yellow or whitish areas between the veins of the leaves. Leaves so affected are usually small in size, stiff and pointed. The branches bearing these leaves appear bushy and stunted.

This condition may be associated with such diseases as withertip and dieback, or it may be an independent trouble. Causes of this disease may be poor drainage, soil conditions, moisture conditions, excess of lime or organic matter. Frenching shows a disturbance of the physical condition of the tree, that may be due to any one or more of several different factors. Trees slightly affected with this trouble often grow out of it in time. Other trees become so weakened that it is necessary to remedy the cause of the disease if it can be located. Frenching is found scattered here and there through the orchard, only certain spots being affected.

**Control**—Slightly affected trees may come out of the trouble without assistance. In bad cases of frenching, it will be necessary to find the factors causing this condition and remedy them.

## FROST PROTECTION AND ORCHARD HEATING

The best citrus fruit is produced near the frost line. The ideal location would be where the lowest temperature reached thirty-three degrees several times during the winter. The ideal, however, can only be approached and the only solution is resorting to orchard heaters when the temperature falls below the danger point. Orchard heating has become a necessary phase of citrus fruit production. Only within the past few

years has it passed from the experimental stage to one of reasonable efficiency. Improved types of heaters and more satisfactory methods of heatings have been developed.

The records of the U. S. Department of Agriculture show that a temperature of from twenty-nine to thirty-two degrees is injurious to green oranges and lemons, and that fully matured oranges will stand a temperature as low as twenty-seven degrees with no serious injury, provided this low temperature is not maintained too long. No definite minimum temperature can be given, because so much depends on the duration of the freeze, and the condition of the trees and fruit. The temperatures mentioned above may usually be taken as the minimum of safety.

Orchard heating is the best insurance policy one can have for his

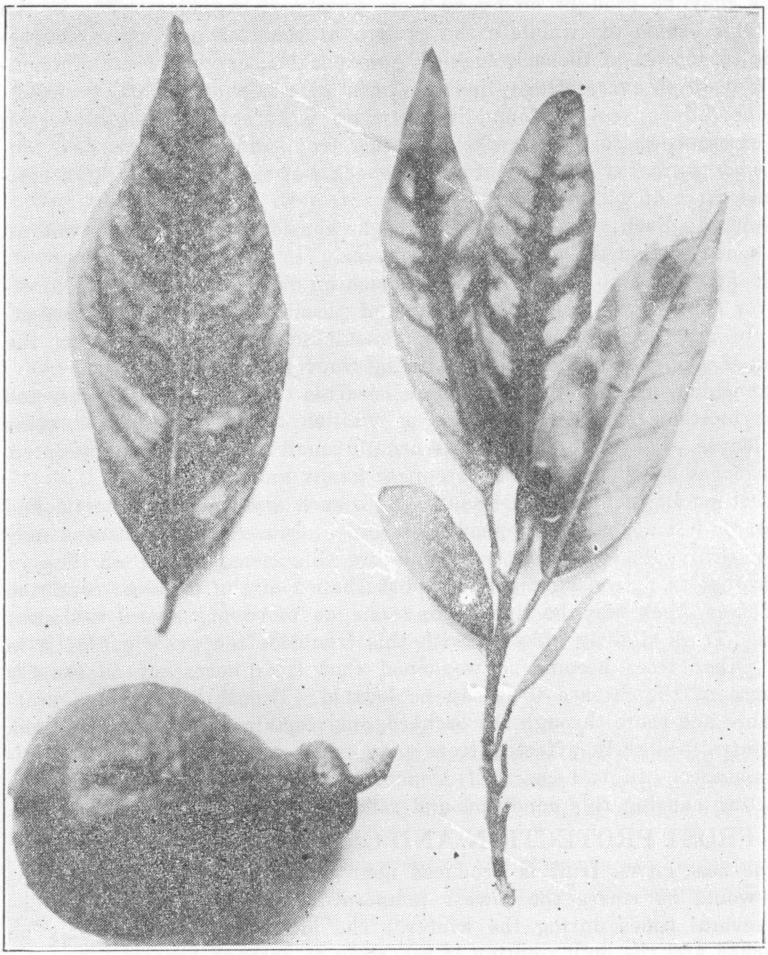

Fig. 37. Leaves and fruit showing Mottle Leaf (Frenching).

orchard. No grower can afford to have the results of at least four years' work wiped out by a freeze, simply because he does not carry insurance, (Proper heating equipment).

Orchard heating is still commonly known as smudging because it was thought at one time that the pall of smoke protected the trees and fruit from freezing. It does not, however, protect from freezes, but it may, like a cloud, prevent too rapid radiation of heat or thawing of the fruit after the freeze. Protection from frost is dependent on the actual raising of the temperature or maintaining the temperature above the danger point.

Fig. 38. Corn stalks or reeds will give some protection from frost.

*There are two kinds of heaters on the market, one using oil for fuel, and the other petroleum coke. When deciding whether to install a coke or an oil heater, the following advantages should be considered:

*There are numerous methods suggested for protecting plants from cold. Only two have gained favor for Texas conditions at this time. These are the oil and coke heaters mentioned above.

**Oil Heaters**—Each heater will use about five gallons of oil every six hours. The oil costs approximately eight cents per gallon, or a total of forty cents ($.40) for six hours per heater. The oil heater is very easy to light. A large storage tank holding several thousand gallons of oil and a tank wagon are required. The heat is quickly available, but is not a steady heat. The heaters are apt to soot up after a few hours of burning and lose some of their efficiency. Much smoke is often given off, blackening trees and buildings.

**Coke Heaters**—About twenty-five pounds of coke per heater is required for six hours burning. The cost is about six-tenths of a cent ($.006) per pound, or fifteen cents, ($.15) for the fuel. Coke is rather difficult to light, and it is thirty minutes after lighting before much heat is given off. Coke is very easily stored and can be kept without deteriorating by piling it up in the orchard. Additional fuel can be supplied without allowing the heater to go out. The heat from this type of heater is close to the ground and is capable of spreading over a large area. There is no smoke and the gasses given off are not injurious to trees.

When using an oil heater, the fuel should be a paraffin base oil of fairly high specific gravity. It should not be lower than twenty-six (26) degrees Baume'. Heavy oil is hard to handle during a cold spell.

Adequate storage should be provided for oil or coke. Steel tanks are the best for oil, as it seems impossible to construct cement tanks that will hold without leakage. Tank wagons and buckets should also be provided. The heaters should be filled and in place before there is any possibility of a freeze, as there is not time to do all of this at the last minute. Adequate help should be arranged for and definite sections of the grove assigned to each crew, so that there will be no confusion. Quick lighting is essential. Fuel is expensive. The temperature often falls very rapidly. Time and money spent in firing drills will usually be highly profitable by saving either fuel or the crop.

A method sometimes used to indicate freezing, in addition to the thermometers, is to fix on a stake about two to three feet high, out in the open between the trees, an ordinary china plate. Put into it a few teaspoonsful of water, just enough to cover the bottom. Examine this water at short intervals and when the first particles of ice are felt, firing should be started for all citrus in bloom, young fruit, and new growth. If the trees are dormant, they will stand one or two degrees more before it is necessary to start the heaters.

The tips of the young growth, the buds and blooms are the first to be injured. The harder the frost and the longer its duration, the farther it will penetrate into the tree. The first half-hour of a freeze causes little damage, but the long period of cold, especially in the latter part of the night, will do much harm.

It is much easier to heat a large acreage efficiently than to heat a small area. Therefore, it is to the individual growers' interest to urge that all growers protect their orchards.

Experience in past seasons has shown that a poorly heated grove is a liability and a well heated grove a very distinct asset. If one does

not have finances to secure sufficient good orchard heaters for his entire orchard, he should have fifty or sixty heaters per acre for as much of his orchard as is possible and then plan to heat the remainder of his orchard with wood fires. In past years, those orchardists who had a large number of good wood fires protected their trees much better than did some who had a few poor heaters.

The grower, above all things, needs adequate, economical protection from frost. He should figure closely the installation costs, operation expense, results obtainable and depreciation of equipment before deciding on his heating apparatus.

Under no circumstances should an orchard be left without some kind of protection.

### Protection of Young Trees

It is a rather general practice to bank earth up about a foot above the bud union of young trees, and wrap the top with corn stalks or some similar material.

This is a good practice if a few precautions are taken, and may prevent the young trees from being badly frozen. Before piling up the earth around the trunk, they should be painted with Bordeaux paste, to which has been added one ounce of crude carbolic acid to each gallon of paste. This will protect the tree trunks from injury by rodents and decay organisms. The packing of the tops should be done well, so that no cold air can circulate through. All packing and earth should be removed before hot weather, to avoid injury.

The time of planting of young trees is important as a factor in frost protection. Trees planted early in the fall that have started growing are much more susceptible to injury from cold than trees planted later in the fall and still remaining dormant.

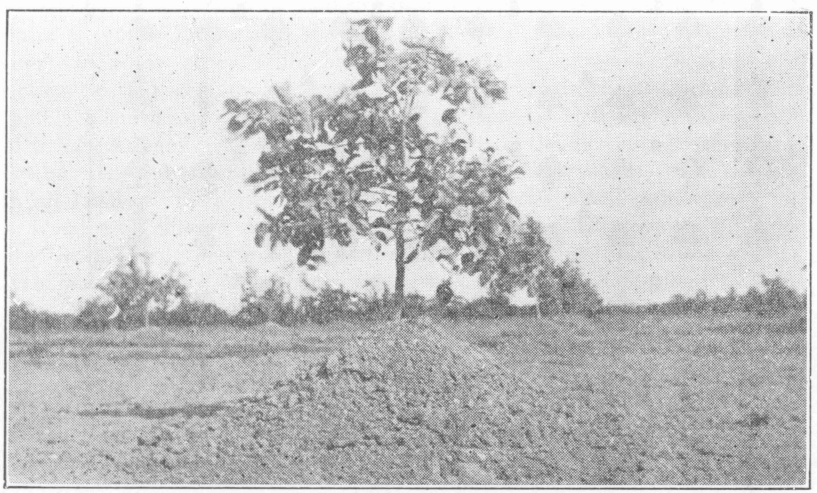

Fig. 39. Young trees with the soil banked up to protect the bud union.

## Directions for Heating

Enough heaters should be used to make the circle of radiation from one heater to overlap that from the next. This will require at least one heater for each alternating tree-square. One heater per tree is still better. A heater should be placed in each opening between trees on all four sides of the orchard as it is impossible to determine before hand the direction of the wind or how it may change. Air movements may come from all four quarters in one night, and it is often impossible to move heaters from one place to another fast enough, and at the same time keep the work in the orchard going on without delay. (See diagram pp. 64).

When the heaters in the orchard are burning, the warm air being lighter than the cold, tends to rise and cold air is sucked in from the outside to take its place. A battery of heaters on all four sides will warm the air coming and tend to stabilize the temperature within the orchard.

**Thermometers**—Thermometers should be placed on stakes in several parts of the orchard, some about a foot from the ground, others about the same height as the tree tops.

Thermometers should never be placed under porch roofs, against houses, in the centers of trees or in any location where obstruction will prevent a correct reading.

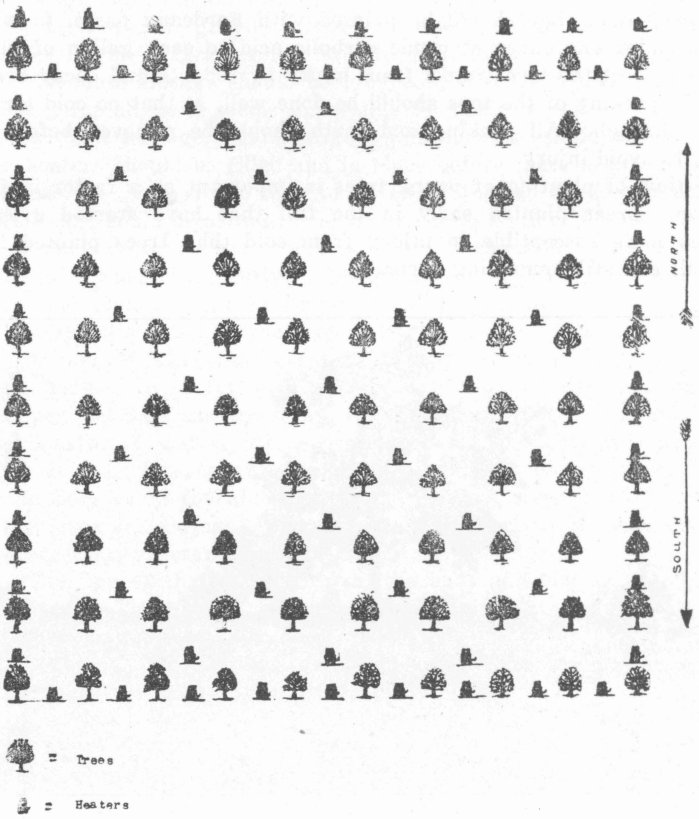


Fig. 40. Diagram of suggested placing of heaters in the orchard.

## MARKETING

Marketing has not only to do with the mere selling of the product but goes much further back than at first may be apparent. The selection of good varieties has a very intimate relationship to sales. The cultural care the fruit receives has a definite bearing on the way it is received upon the market. Harvesting methods may entirely destroy the value of otherwise desirable products. Each step in fruit production should lead to the final satisfied customer. Each step is a necessa y approach to the final goal: if wrong, may cause the failure of all.

Fruit production is a highly specialized business and so calls for special methods. It calls for a careful study of the nature of the product handled and of the demands of the consuming public. Yet through it all there is found that good common sense that must be the basis of sound industry.

Fruits are living organisms. This fact must be kept in mind in all fruit handling operations. Each of them have a more or less definite life span during which they are edible. Methods of handling should be such as not to shorten this period but to extend it to its fullest extent. Injury opens the way for decay producing organisms and causes premature death of the fruit. Citrus fruits are not as highly perishable as others. This has frequently led to very careless methods in preparing them for market. On the other hand citrus is frequently held for long periods in storage or upon the grocer's shelf so that deterioration may be as severe as with the more delicate sorts.

The grower's interest in his fruit does not cease with its sale to the buyer or with its acceptance by the packing house. His interest continues until the fruit reaches the consumer's table. The sounder the fruit the wider its distribution and so more ready sales.

**Picking**—Most varieties of citrus will hang on the trees for sometime after coloring without deterioration. This is very desirable as it permits a longer harvesting season and does not usually mean the rush incident to some other fruit harvests. It often happens that certain varieties or that certain factors will cause the fruit to sweeten-up and be edible some time before it is properly colored. Frequently early fall fruit brings a fancy price so that there has arisen the custom of harvesting sweet but still green fruit and artificially coloring (sweating) it as is done with all lemons. Such practices gave rise to abuse since immature fruit was frequently colored and put upon the market. To prevent this the United States Drug and Food Department made a ruling that oranges must contain not less than eight parts sugar to one part of acid. So far few, if any, Texas growers have practiced artificial coloring but there is no reason for their not doing so if the fruit is sweet and wholesome.*

Good tools mean better work and less injury to the fruit and trees. Each grower should arrange for these sometime in advance of picking

*Briefly the sweating process consists of placing the fruit in a tight room and subjecting it to the gas produced by incomplete combustion of kerosene, accompanied by high humidity and rather high temperatures.

season. Some form of the open bottomed duck picking bag has been found satisfactory. These leave the picker's hands free and enable him to cut the fruit stems close and place it in the bags with a minimum of injury. It is generally advisable to have especially constructed field boxes of not too large capacity. The large boxes are difficult to handle and cause much bruising of the fruit. All citrus are clipped from the tree—never pulled. For large trees, ladders will be necessary. These should be provided with three legs. Ladders leaning against the tree frequently break many branches. The wagon or truck for hauling the fruit should be provided with springs and precaution taken to avoid rough roads.

When the fruit is cut from the tree the rind is turgid and brittle. Under such conditions it is much more readily injured than after it has wilted a little. For this reason, some growers permit the fruit to stand for several hours in the field boxes under the shade of a tree before hauling and in the packing house two or three days before grading, sizing and packing.

The following are some of the ways citrus fruits are injured by picking: Tossing or dropping into bags, boxes or other receptacles, pulled fruit, punctures from long stems, clipper cuts, dead twigs and splintered boxes, abrasions from sand or grit in boxes or bags, finger nail scratches and squeezing the fruit in hands or against the ladder. In careful grading any one of these make a cull out of a good fruit. If packed and sent to market they may rot in transit or will be sufficiently apparent by that time to materially reduce sales.

Grading—Grading is based upon quality. Quality is undefinable but has to do with the texture of skin, color, freedom from injury and blemish, juice, aroma, the blending of acid and sugar, freedom from fiber and seed. Based upon these, citrus is usually divided into three grades—fancy, choice and standard. In some sections where the rust mite or melanose occur another class is made, known as russett, with the same grades as above. Within each of these grades there are several sizes and the price is based upon a combination of grade and size.

For a fruit to be classed as fancy it must be nearly perfect. The skin must be fine and smooth, the color high, free from thrip scars, leaf rub, insect injury and other blemishes. It must be heavy, indicating lots of juice. So far there has been little fancy fruit sent out of the Valley. It has been found that the grower, by proper management, can increase his percent of high grade fruit.

Washing and drying is usually done before the fruit passes before the graders. It has been proven that washing increases decay so that it is not done unless necessary. If the fruit is dirty, however, the improvement in appearance will usually offset loss from decay.

The fruit passes before the graders on movable belts. They switch the grades to other belts which deliver them to the sizer. How many grades will be made is determined by the packing house or association. Grading calls for skill and experience and must be done by disinterested persons, women have been found especially good for this work as well as for packing.

**Sizing**—Oranges and grapefruit are sized by machinery. Oranges are usually divided into sizes running from 80 to 300 per box, the 176, 200 and 216 sizes being most popular. Grapefruit is sized from 36 to 126 to the box, the ones running 54, 64 and 70 per box being most desirable.

**Packing**—It requires considerable skill to pack oranges sizing from 80 to 300 into the same sized box and have them come out snug and tight. And yet this has to be done if the fruit is to get to the market in good condition and have an attractive appearance. Each size has a specific arrangement that must be strictly observed if a successful pack is maintained. All citrus are wrapped in soft tissue paper and so arranged in the boxes as to prevent movement and bruising. The grower's or association's name is usually stamped upon the wrapper and upon the box label.

**Distribution and Sales**—Up to this time the returns for Texas citrus have been good but with increased production it will be necessary to make a greater effort to insure profit. More careful grading for soundness and quality will have to be followed if the Valley growers successfully compete with the great citrus areas of California, Florida and West Indies. Texas' claim to superior fruit has not been established upon a competitive market and will not be unless more care is given to standardizing products. Only sound high class fruit should be started to market. The consumer has been getting very satisfactory fruits from the sources just mentioned. Texas fruits must show some superiority if new consumers are gained.

The Valley grokers should market as a unit through an association or some other agency. To the average grower it offers facilities that he cannot secure in any other way and is the only means of establishing a standard. Later the Valley associations should join hands with those mentioned above to form a National Exchange so that all consumers may be supplied and yet gluts and losses avoided.

Carefully graded fruits permit a wide distribution. After the car reaches its destination the product may be held successfully a few days or reshipped by express to secondary markets. Oranges may be bought at every cross road store. Texas oranges must be so grown, handled and distributed as to meet this competition. Texas fruit must be sought by the car lot wholesaler, not accepted with apprehension.