Citrus Culture in the Arid Southwest.

By J. Eliot Coit.

Tucson, Arizona, December 21, 1908.
UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION.

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The Experiment Station office and the botanical and chemical laboratories are located in the University main building at Tucson. The range reserves (cooperative, U. S. D. A.) are suitably situated adjacent to and southeast of Tucson. The departments of agriculture, horticulture, and animal husbandry conduct operations on the Experiment Station farm, 3 miles northwest of Phoenix, Arizona. The date-palm orchards (cooperative, U. S. D. A.) are 3 miles south of Tempe, and 1 mile southwest of Yuma, Arizona, respectively.

Visitors are cordially invited, and correspondence receives careful attention.

The Bulletins, Timely Hints, and Reports of this Station will be sent free to all who apply. Kindly notify us of errors or changes in address, and send in the names of your neighbors, especially recent arrivals, who may find our publications useful.

Address, THE EXPERIMENT STATION,
Tucson, Arizona.
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Fig. 1. Orange grove in Salt River Valley irrigated by the basin system.
CITRUS CULTURE IN THE ARID SOUTHWEST

By J. Eliot Coit.

GENERAL DISCUSSION.

The climatic conditions under which citrus fruits may be grown differ widely. In the particular region discussed in this bulletin, three extremes of climate are combined. Here we find that lowest rainfall, lowest relative humidity and greatest percentage of sunshine occur together; and this is true to the same extent of no other area in North America. The shaded portion of the map in Fig. 2 represents that part of the inland arid Southwest where temperature limitations permit the growth of citrus trees. This area is, of course, still further limited by such factors as water supply, suitable soil, etc.

Notwithstanding such trying climatic conditions, orange trees have been grown for nearly twenty years at Phoenix and Yuma, Arizona, and for a much longer period at Hermosillo, Sonora. As the country becomes more thickly populated and new railroads open up additional acreage, citrus growing is being gradually extended to many other localities. All through the mountains of southern Arizona there are comparatively frostless coves and foothills which may be made to produce an abundance of high quality oranges and pomelos for home consumption. In each case, however, the very important problems of water supply and transportation will have to be solved before these pioneer plantings may be enlarged into commercial groves. Examples of a few such places are Agua Caliente, seventeen miles east of Tucson; Agua Caliente, northwest of Gila Bend, and areas near Parker and Fort Mojave. Extending for considerable distances south of Parker, on both sides of the Colorado River, there are bench lands suitable for citrus culture. In general, the limits of such citrus areas may be determined by the following factors: elevations not exceeding 2,500 feet; winter temperatures not
below twenty and rarely below twenty-four degrees F., and a reliable supply of irrigation water.

The incentive to grow oranges in the arid Southwest, where climatic conditions are trying to the growth of the trees, is the high price received for the fruit. Fruit from this region is in considerable demand in the Northern markets, chiefly on account of its remarkable earliness. The oranges are also sweeter and are much deeper colored than those grown in humid and less sunny regions.

The question is often asked: "Just how free from frost must a location be to warrant the planting of citrus trees?" This question admits of no definite answer, since several things must be taken into consideration. It depends on the kinds of citrus fruits planted, the age of the trees, the health of the trees, the length of time the cold lasts, and perhaps most of all upon the condition of the trees as regards dormancy. A perfectly healthy dormant Navel orange tree of good size may withstand a temper-
ature of seventeen or eighteen degrees for several hours without being seriously killed back; while the same tree if weakened by gum disease or insect enemies, or if the sap has been started slightly by a few warm days, may be killed back to the trunk by twenty-two to twenty-four degrees lasting for the same length of time. In the case of the late maturing varieties, cold sufficient to injure the fruit may not kill the twigs.

In selecting a site for an orange grove, there is usually no better place than the elevated south slopes which lie about the base of a much higher elevation, such as a butte or mountain. From such places on frosty nights the heavy cold air flows downward seeking the lower levels in the valleys, thus keeping up an air movement among the trees which tends to prevent frost. It is quite possible also that the large bare rocks on the hillsides, which become heated up by the sun during the day, may exert an appreciable influence in warming the air which is drawn down past them during the night.

The lands along the river in Salt River Valley, and in the vicinity of Phoenix and Tempe, are usually subject to a comparatively large number of frosty nights during the winter, and for this reason citrus growing on a large scale is not at present attempted. The same may be said of the greater part of the Colorado Valley below Yuma. It is true that the flat valley lands around Hermosillo, Sonora, are comparatively frostless, but this is doubtless due to its geographical position far to the southward, and to the fact that its elevation above the sea is only 690 feet. In large protected inland valleys, such as the Salt River Valley, slight variations in altitude make a great difference in the frostiness of the winters. The elevation of Phoenix is about 1,100 feet, while that of the Ingleside orange grove on the foothills of Camel’s Back Mountain is only 1,300 feet. The most successful groves at present are located along the Arizona Canal west of Scottsdale, ranging in elevation from 1,150 to 1,300 feet. Perhaps a greater elevation than that of Ingleside would be even more desirable. When electric power for pumping becomes available, more elevated sites for orange and lemon groves will doubtless be selected on the north side of the canal, where suitable soil may be found. On the south side of
the river, along the foothills of the Salt River and Estrella mountains, there are many places where the only hindrance to citrus culture is the ever present water problem.

At Yuma the transition from valley to mesa is very abrupt, most of the valley being subject to frosts, while the broad mesa or table-land lying south of the junction of the Colorado and Gila rivers and extending into Mexico is free from destructive frosts.

The following tables afford a comparison of the minimum winter temperatures for Porterville and Riverside, California, the Blaisdell Heights near Yuma, and the vicinity of Mesa in the Salt River Valley. The Mesa figures, though for but a short period of time, are all that are available.

TABLE I.
MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FOR PORTERVILLE AND RIVERSIDE, CALIFORNIA; DERIVED FROM U. S. WEATHER BUREAU.
(FROSTY TEMPERATURES IN BLACK-FACED TYPE)
Elevations: Porterville, 464 feet; Riverside, 831 feet.

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TABLE II.

WEEKLY MAXIMUM AND MINIMUM TEMPERATURES TAKEN IN THE
PROSPECTIVE ORANGE AREA ON YUMA HEIGHTS, ARIZONA;

DEGREES F., BY H. W. BLAISDELL, YUMA.

(FROSTY TEMPERATURES IN BLACK-FACED TYPE)

Elevation 200 feet.

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One of the many important factors which help to determine the success or failure of every orange grove is the soil. Orange trees are occasionally known to be successful on light sand or heavy adobe, but such soils, especially the adobe, entail much more labor in their management and are not nearly so sure of success as the ideal orange soil. Such a soil may be roughly described as a deep and rich alluvial or colluvial deposit, made up in part of decomposed granite and limestone. It should by all means be in such physical condition as to absorb water rapidly.
and be easily cultivated after irrigation. Before locating an orange grove, a thorough examination of the soil to a depth of ten feet or more is very important. If a hard impervious layer of caliche is found within three or four feet of the surface, the permanent success of the future orchard is questionable. On the other hand, layers of open gravel or very porous sand near the surface are apt to favor diseases and various physiological troubles, such as mottled leaf, etc.

The soils of southern Arizona usually have an abundance of potash and phosphoric acid, but are especially deficient in humus and, consequently, in nitrogen. Many of our desert soils while in the virgin state are so devoid of humus as to make them physically undesirable for orange trees. Such soils are mere beds of mineral matter, and when water is applied they consolidate and bake until it is very difficult to work them. This often takes place before available men and teams can complete the cultivation of a large grove after an irrigation. Orange trees grown on such soils do not make as vigorous a growth nor produce the quantity of fruit that they do on soils of greater humus content.

The remedy for this undesirable condition lies in the addition of humus. This may be accomplished by growing alfalfa for a few years before the trees are planted, and turning it under, or by incorporating into the soil, between previously planted young trees, such summer and winter crops as are recommended on pages 304-6. In certain cases where stable manure is available in quantity, and at a suitable price, its thorough incorporation with the soil is the quickest way to increase the humus content and, consequently, the water-absorbing capacity of the land. On the other hand, an excessive use of stable manure is dangerous, as it produces a coarseness of the fruit characterized by thick and puffy rinds. Fruit of this kind does not keep in storage as long or ship as well as fruit with smooth firm skins.

The average soils of the arid Southwest contain more potash and phosphoric acid but less nitrogen than those of the established citrus districts of California. It is therefore evident that after the nitrogen content of Arizona soils is sufficiently increased by the addition of humus, they are satisfactorily fertile. This is
shown to be true by the fact that in certain orange groves of the Salt River Valley, and also at Hermosillo, where proper attention has been given to the humus content of the soils, the trees attain as large size and produce as much fruit as they do in the San Joaquin Valley of California.

Lands containing alkali in injurious amounts are, of course, unfit for the growth of citrus trees. Such lands, however, are rarely met with in the orange belt. They are generally limited to the lower parts of the valleys, especially where the drainage is poor. These lands are, therefore, on account of their position, too frosty for citrus culture. It sometimes happens that on land comparatively free from alkali, a lack of intelligent methods of irrigation will bring about a concentration of salts at the surface of the soil. This may be quite injurious, or even in rare cases fatal, to the trees, but the remedy lies in improved methods of applying the water as explained under "Irrigation," on subsequent pages.

As before stated, citrus culture in any part of the arid Southwest is entirely dependent on irrigation. The orange tree is naturally shallow-rooted, filling the surface soil with a mass of fibrous roots which quickly perish if not well supplied with water.

In the early days of orange culture in the Salt River Valley, the irregularity and unreliability of the water supply constituted the chief hindrance to the success of the industry. The light brush dams which were used to divert water from the rivers into the canals were liable to be washed out with every summer flood, thus leaving the orange growers in a peculiarly helpless condition for many weeks at a time. This uncertainty of the water supply deterred small ranchers with limited capital from investing very heavily in citrus trees. It was therefore left, to a large extent, to the old canal companies themselves to plant the original orange groves of Salt River Valley; but with the building of the Roosevelt storage reservoir and the Granite Reef diversion dam by the U. S. Reclamation Service we find conditions changed. Judging from the progress made in the former, and the completion of the latter enterprise, it would seem safe to predict a regular water supply for the orange belt at an early day. Government supervision of all canals and laterals will,
also, bring about an equitable distribution of water in times of shortage.

The many thousands of acres of orange land on the mesa near Yuma are to be supplied with water from the Colorado River by the U. S. Reclamation Service. The Laguna dam on the Colorado fourteen miles above Yuma is already approaching completion, but such an amount of work is yet to be done that a year or two will necessarily elapse before actual planting of mesa lands can begin. For fifteen years an orange grove now seventy acres in extent has been maintained on the mesa by Mr. H. W. Blaisdell. The exceedingly muddy river water has been pumped directly to a cement lined settling tank near this grove, where a part of the silt is allowed to settle out before the water is applied to the trees. If this grove is taken as an index of the possibilities of the whole country lying around it, the success of the citrus industry at this place seems fairly well assured.

It is quite evident from a glance at the map that the citrus growing areas of the United States, though comparatively small, are at a great distance from the large markets. It is therefore necessary to locate all citrus groves, the fruit of which is intended for shipment to market, at or quite near some railroad station. It is hardly necessary to remind prospective investors that a great advantage in rates and dispatch is often secured by so locating a grove as to be able to ship over either of two or more lines of transportation.

PROPAGATION AND PLANTING.

Citrus trees may be propagated in three ways,—by cuttings, by layering, and by budding upon seedlings, of which the last mentioned is the only method used in a commercial way. Arizona planters may secure budded trees from Florida or California nurseries, or they may grow them themselves. Florida, however, is a dangerous source of supply on account of the liability of introducing injurious insects and diseases. A good grade of citrus stock may be purchased in California with less danger of the introduction of pests; but the present high prices maintained by California nurserymen, together with very high freight rates on balled stock, make California trees very
expensive. For these reasons the question has been raised as to the practicability of producing citrus nursery stock in Arizona and as to whether stock so produced will compare favorably in size and vigor with the California grown article. There is an impression current in Salt River Valley that home grown trees are acclimated and therefore the more to be desired. Whether this is true or not, time and experiment can alone determine.

In attempting to grow orange trees from seed, the water supply should be ample and preferably under the complete control of the grower. Pumped water is therefore best, as it may be had whenever needed and can be handled through pipes and rubber hose. The soil should be a fine, well drained, sandy loam, containing enough organic matter to enable it to absorb and hold much water and not bake on the surface. Over the area selected a lath-house should be built. This is a simple structure with a flat roof usually placed eight feet from the ground. The roof is sustained by upright supports either 2 by 4 inches or 4 by 4 inches according to the distance apart. Across the tops of these are nailed 1 by 3 inch runners, and upon these in turn are tacked 1 1-2 inch laths (which may be had in long sizes convenient for the purpose) with one inch spaces left between. Where date trees are available, as at Hermosillo, the long leaves which are annually pruned from the trees, are a very cheap and satisfactory substitute for the lath, though their spines make them unpleasant to handle and they are more liable to be blown off or disarranged by wind storms. The covering should be extended to the ground on all sides of the enclosed area. Seedlings grown under such a shelter are partly shaded from the hot sun and protected from the drying winds which are so apt to damage the tender foliage of very young plants.

Under this partial shade the soil should be thoroughly and deeply worked into a fine state of tilth. After being rolled until it is level and slightly compacted, it is ready for planting. Seed may be bought from seedsmen or it may be collected and saved at home. In any event it should never be allowed to become dry, as this greatly injures its viability. If it is necessary to keep the seed for any length of time before planting, it should be mixed
with damp sand and packed in boxes under four or more inches of sand to prevent sprouting. The proper time to plant orange seed is in the spring after all danger of frost is passed. After being sprouted in warm water, the seed should be distributed broadcast about one inch apart each way over the surface of the soil. While doing this the planter stands on a wide board which he moves back after each strip of about two feet is finished. Immediately on the completion of each of these strips, the seed should be covered to a depth of one inch with clean fine sand. Great care must be exercised in selecting clean sand, for if it contains any quantity of vegetable matter, serious losses from damp-off fungus will likely occur. It is desirable that the water be conducted through pipes to convenient points in the lath-house in order that the surface of the sand may be sprinkled in such a way as to maintain just the proper degree of moisture to favor germination. Watering with the hose is greatly facilitated by leaving twelve-inch walk-ways about every twelve feet. Careful watering is very important. Too little water permits the seeds to dry out while too much causes them to rot. Carelessness in watering after the plants are above the ground is almost sure to result in damping off of the seedlings. The plants remain in this bed for about one year, when they are transplanted to nursery rows twelve or fifteen inches apart in the row. It is likely that under arid climatic conditions these nursery rows should also be sheltered by a lath-house. Here they may receive thorough cultivation and constant attention for another year. An orange nursery is a favorite place for gophers, and unless these rodents are persistently fought they will do great damage.

Orange seedlings should be ready to bud when two years old, though undersized individuals may be left and budded at three or even four years of age. This work is usually performed in the spring at the time the new growth starts, though it is sometimes done in the summer or fall. When done in the fall it is called dormant budding, and such buds do not start until the following spring. The ordinary way of budding citrus stock is by the shield or "T" method. For full details of this process the reader is referred to any book on horticulture or to U. S. D. A. Farmers' Bulletin No. 157.
When the trees have attained sufficient size after being budded, they are ready to be planted out in permanent orchard form. Thorough preparation of the land for the orchard is, of course, very important and has a great deal to do with the success of the grove. It should be deeply plowed in both directions, and then harrowed until it is reduced to the finest state of tilth. For the region under discussion the following spacing is recommended:

<table>
<thead>
<tr>
<th>Kind of tree</th>
<th>Distance apart in feet</th>
<th>No. of trees per acre</th>
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<tbody>
<tr>
<td>Dwarfs, such as Satsumas and Tangerines</td>
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<tr>
<td>Washington Navel and Mediterranean Sweet</td>
<td>20 x 24</td>
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<tr>
<td>Sweet Seedlings</td>
<td>30 x 30</td>
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Large holes should be dug and the trees removed to them with thirty or forty pounds of undisturbed earth about their roots. This earth may be kept in place by tying around it a piece of old sacking which need not be removed when the tree is set into its permanent place. Trees prepared in this way for moving are known among California nurserymen as "balled stock." Such stock is more to be desired than that from which the earth has been removed. It ships better and requires much less cutting back when planted. On the other hand, the additional freight on such stock is often a serious item.

In planting an orchard it is very important that the trees be set exactly in line. In order to accomplish this stakes should be set the proper distance apart; then by sighting in both directions and by a little shifting perfect alignment may be secured. As the stakes have to be moved when the hole is dug, it is often difficult to set the tree so that its trunk will occupy the exact spot previously marked by the stake. This difficulty may be overcome by the use of the notched planting board shown in Fig. 3. Before the stake is removed this board, which should be about twice as long as the hole is wide, is so placed that the stake fits into the notch. Stout pegs are then pushed through the holes in each end into the ground. One end is then raised and the board swung back out of the way. After the hole is dug
and the tree placed, the board is returned to its former position and the tree so adjusted that the trunk fits into the notch.

In a dry climate it is especially necessary to pack the soil firmly about the roots so as to bring them into intimate contact with the damp soil. If the roots are not balled it is very important that they be wrapped in wet sacks, never allowing them to become dry while being distributed in the field. When placing the trees in the holes they should be turned so that the bud union will be toward the northeast, and thus be protected from the afternoon sun. This union should always be just above the ground after the tree is planted and settled. After planting, water should be immediately run through furrows on each side of the row of trees; but great care should be taken that no water comes in contact with the bark of the trunk as this often causes gum disease. The work of planting an orchard should be completed between the time of the last heavy frosts and the hot days of early June. In any event, the trees should be moved only when they are dormant. Citrus trees, being evergreens, have several periods of growth and dormancy each year. They may be transplanted at any of these periods, but it is considered best under arid conditions to transplant during the winter dormancy, just between the last heavy frosts of February or March and the spring growing period. It often happens that the trunks of young trees, being unprotected at first by foliage, will sunburn on the southwest side. For this reason it is necessary to protect them with yucca tree-protectors, or with newspapers or palm leaves tied around the trunks.

Trees at this age are peculiarly susceptible to frost injury, and far greater care must be given them during the first three years in the field than is necessary at any subsequent time. They may be protected to a certain extent on cold nights by
smudging with wet straw, or by burning coal, wood, or crude oil at intervals throughout the grove. But it must be remembered, as before stated, that the degree of cold an orange tree will endure depends in large measure upon its dormancy. Many regard windbreaks as a means to secure frost protection, but it is doubtful whether a windbreak gives this protection except in very rare cases. It is often desirable to have the orange grove surrounded by a thin line of evergreen trees, such as Eucalypts and pepper trees. These add a great deal to the attractiveness of the groves and break the force of the summer sand-storm winds, which cause much injury by blowing the branches about and throning the fruit. If the windbreak is planted too close and allowed to grow compact like a pomegranate hedge, the tendency is to stop the currents of air which mean so much in the way of frost protection. In other words, a windbreak if properly grown is a good thing in Arizona; but a wind-stop may make a frost pocket of the grove.

STOCKS FOR CITRUS TREES.

The most important stocks used in the propagation of citrus fruits, mentioned in the order of their hardiness to frost, are trifoliate orange, sour stock or Seville orange, sweet orange, pomelo, rough lemon, and lime. No one of these is best suited to all conditions of climate and soil. It is therefore evident that discrimination should be used in deciding which stock to make use of for a given citrus grove. These different stocks vary considerably in their root development and soil foraging powers; also in their resistance to cold and in their effect upon the scion which is budded and grown upon them.

The special value of the trifoliate stock lies in its extreme hardiness to cold. It transmits to a limited extent this frost resisting power to the scion. Having fine, fibrous roots in great abundance, it is a strong feeder. It dwarfs the scion to a certain extent and throws it into very early bearing. Mr. G. L. Taber of Florida planted a test grove of twenty standard varieties of oranges, the trees budded on trifoliate and sour stocks alternating in the rows. In "Farmer and Fruitgrower," 1902, he reports that twenty-seven months after planting the average number
of fruits upon trees on trifoliate stock was sixty-four, while the average number of fruits upon trees on sour stock was eleven.

It should be remembered, however, that old and experienced orange growers are by no means united in praise of the trifoliate as a hardy stock. Some state that they have repeatedly seen it stand less cold than sweet seedling. The fact that this stock is uncongenial to the scion is shown by its dwarfing effect. It is thought by many that the scion on trifoliate root will lose more hardiness from lack of vigor due to uncongeniality of the stock than it will gain directly from its hardy nature. While the trifoliate as a stock may be of proven value for the hammock lands of Florida, it has certainly not passed the experimental stage in the arid Southwest and should be used with great caution.

The sweet seedling stock was formerly largely used in California and opinions differ as to whether this or the sour stock is best under conditions there. Sweet stock has a shallow root system with few or no tap roots, and is impatient of a limited water supply.

Sour stock on the other hand has large strong tap roots which descend deeply into the soil. It is much more hardy to cold than sweet stock, and is not nearly so subject to attacks of mal-di-goma, or foot-rot disease. The sweet orange is quite subject to this trouble.

The pomelo is of late years coming into more general use as a stock, though it has not yet been thoroughly tested under arid conditions. It is a very wide and deep feeder and transmits vigor of growth to the tree. It does well on high and dry soils and is not subject to foot-rot disease. The seeds are large and germinate readily in the nursery row, making strong, vigorous seedlings.

The rough lemon and the lime are both used as stocks in tropical countries, but they are so tender to frost that they should be avoided in the arid Southwest. It is poor policy to experiment on stocks of doubtful merit when the great superiority of others has been demonstrated.

To sum up then, we find that for the typical citrus areas of the arid Southwest either the sour or the sweet stock should be used, the special advantages of each measuring up about the
same. On the edges of these citrus areas, and in locations where the severity of the frosts is uncertain, trifoliate stocks may be used, for even if the trees should be frozen back to the trunk, their early bearing tendencies enable them to recuperate and come into bearing again with minimum loss of time.

**ORCHARD TREATMENT.**

*Cultivation.*

Clean and thorough cultivation in the summer and a leguminous cover crop during the winter, is unquestionably the best management for Arizona orange groves. Thorough tillage not only puts the soil into condition to take irrigating water more readily, but checks evaporation from the soil surface. Cultivation, also, secures aeration of the soil, with consequent access of oxygen to plant roots; and it promotes the action of those soil bacteria which render plant food available. But clean culture the whole year round as practiced by some, is not wise, for, especially in the hot, dry climate of the Southwest, the humus is by this means oxidized and exhausted from the soil. As stated in the introduction, one of the chief troubles with Arizona soils is their deficiency in humus, and it is necessary that we improve the humus content of our soils if we wish an orange grove to be permanently successful. This can best be done by growing some leguminous cover crop, such as sour clover, *Melilotus indica*, during the winter months and turning it under in the spring. The seed of this clover may be secured at little cost from flouring mills where it is separated from the grain before milling. It should be broadcasted in late September or early October at the rate of about fifty pounds of seed to the acre. It will make some growth in the fall and remain pretty much at a standstill during the coldest weather. With the first warm days of spring it makes an enormous growth and produces from fifteen to twenty-five tons of green vegetable matter to the acre, which when turned under decays and gradually assumes the character of humus. A note of warning should be given here. In sowing sour clover seed which has been bought at flouring mills, one is liable to get seed which contains some Johnson grass, and a close watch should be kept during the summer for this and other
Fig. 5. Fall cover crop of morning glory and grass, with high density of trees as practiced at Hermosillo, Sonora.
weeds scattered with the sour clover. Johnson grass should be kept out by pulling the seedlings before they become permanently rooted.

Some growers use two cover crops a year, one of sour clover in the winter and one of grass and weeds during July and August. This plan is a good one so long as the summer cover crop is allowed to occupy the ground only during the season of summer rains, and is thoroughly disked in by the middle of September. A summer cover of cow peas would be even better than one of grass, for they would add to the soil a large quantity of that much needed element, nitrogen. This may be added directly to the soil by the application of nitrate of soda or sulphate of ammonia, but since these fertilizers are very expensive, the growing of leguminous cover crops which supply both humus and nitrogen is to be preferred.

Irrigation.

It is of course impossible to maintain an orange grove anywhere in this arid country without a dependable supply of irrigating water. The orange grower who derives his water from a pumping plant has a decided advantage over the man who is dependent upon the ordinary canal. The orange grove which is sandwiched in between alfalfa ranches must take its water in a large head for a few hours only. This necessitates a hurried irrigation which gives no time for deep soaking. For best results, the water should be conducted in a head ditch or flume along the upper side of the grove and should be allowed to flow in very small streams into deep furrows along the tree rows. Sometimes several days may be required for the water to reach the lower ends of the rows. This method allows the water time to soak in deeply and reach all the lower roots, encouraging their growth. If these furrows are always run straight down the rows in the same way, there is danger that the water continually rising and evaporating about the bases of the trees may in time cause at these points a concentration of alkali sufficient to injure or destroy a portion of the root systems of the trees. This very undesirable condition may be remedied by throwing up borders on each side of the tree rows and thoroughly flooding them.
Water sufficient to thoroughly soak the ground and redistribute the salts should be applied at this time. It should be borne in mind that the amount of salts contained in the ordinary citrus soils of this region is not sufficient to injure the trees so long as it is distributed throughout the soil. It is only when, by poor methods of irrigation, soluble salts are concentrated in certain parts of the soil that they become a menace.

The check system is more thorough than the furrow system and effectually prevents the rise of the alkali; but it entails more labor and there is more danger that the water will come in contact with the bark of the trunk, causing gum disease. It is much better to give a grove a thorough and deep soaking once in three weeks than to run the water hurriedly through shallow furrows every eight days, as is so often done in Salt River Valley.

Pruning.

Orange trees as a rule require much less pruning than stone fruits, but this does not necessarily mean that such pruning as must be done is unimportant or may be entrusted to inexperienced or careless hands. The most painstaking pruning should be done at the time of planting. At this time the tree should be severely headed back to about twenty inches. This forces it to branch out low and form its main framework near the ground. In former years the trees were headed some five or six feet from the ground, leaving the trunk bare. It has been found much more desirable to head low and prune so that the branches may sweep the ground. This protects the trunk from the rays of the sun and also to some extent from cold. The fruit is much more easily harvested from low headed trees and the branches shade and mulch the soil. After the young tree is once well headed and shaped, it is only necessary to do light annual pruning, when all dead wood should be removed and the inside branches somewhat thinned out. A thick canopy of leaves should be maintained, for it is the common observation in Arizona groves that the most fancy fruit grows in the shade. The sun is so intensely hot that there is a tendency for those oranges which are fully exposed to bake and blister. Often rapid growing sprouts will
break out from the trunk and push their way up through the top of the tree. These should not all be removed but some should be left to renew the top of the tree, the older and weaker branches being taken out from time to time. The main idea in orange pruning should be slow but systematic renewal.

If the trees have been slightly injured by the cold, they should be left alone until the injured twigs have become dry, when they may be broken out. Small trees are much more susceptible to cold than large ones, and in case they are badly frozen and the trunks killed they should be cut off near the ground, thus promoting the growth of new sprouts of which all but the strongest should be cut away. If this rises from the root it should be budded when it attains proper size.

The pruning of the lemon is quite different from that of the orange. The tendency of the lemon is to blossom and grow almost continuously throughout the year. It is very prone to throw up through the top of the tree long ungainly shoots, which rob the lower bearing limbs of sap, causing the lemons to be under sized and of poor quality. It is good policy to head lemon trees low, keep the top cut back and all wayward shoots pinched in. This forces the sap into the fruit-bearing horizontal branches, and at the same time keeps the tree down where the pickers may reach all the fruit from the ground. Attention must be paid to keeping the body of the tree thinned out so that the fruit may be evenly distributed and the pickers not impeded in their work. In pruning any kind of citrus tree, the superfluous sprouts from the trunk should be rubbed off. The main annual pruning and the thinning of the trees had best be done immediately after the fruit is harvested.

It is often desirable to change the tops of old trees from one variety to another. This may be accomplished in several ways. A part of the top may be removed and buds inserted in the bark of the large limbs near the crotch; or the entire top may be removed in the spring and buds inserted on selected sprouts which push out; or the larger limbs may be lopped off some distance out and buds inserted either into the old wood or into the new growth as it appears. Whichever method is pursued, the exposed trunks will sunburn badly unless protected by palm leaves or by white-
wash. In case the entire tops are removed from the trees, sprouts will start out all over the trunk. These should not be broken off at once or too much sap will go to the buds and "drown them out." If these sprouts are left they will take up the sap after drawing it by the buds in a steady stream. They may be cut out by degrees as the buds grow into shoots. These bud shoots have a tendency to grow too long and slender, and should be pinched back frequently to make them branch and grow stout. When cutting off the top of an orange tree, it is a good plan to apply a coat of melted beeswax to all cut surfaces to prevent them from drying out and cracking.

Picking and Packing.

In this day the packing of citrus fruits has become a fine art. It is usually performed at some central packing house operated by a citrus growers’ association. Here the curing, grading, and packing is done by experts. This makes a uniform unprejudiced pack possible, whereas it would be impossible for each grower to attain the same grade of uniformity in packing his own fruit. Uniformity in any grade of fruit from a given region is of the greatest value in building up and maintaining a market. The success of packers, however, in delivering fruit in first-class condition at distant markets depends to a certain extent on the care of the grower in handling his fruit. The skin of an orange is proof against attacks of blue mould and other rots only so long as it is free from bruises or abrasions of any sort. Oranges and lemons should be cut from the tree with clippers so as not to tear the skin. The clippers should have rounded points and the stems should be cut smoothly close up to the fruit. The oranges should be picked into cloth bags or cloth-lined baskets and always handled as though they were eggs. When first taken from the trees the skin is very thick and the cells are charged with water to their utmost capacity. In this condition the rind is very tender and susceptible to injury by abrasion. After the oranges are piled up in the picking boxes and stored in the curing house for four or five days the rind dries out and shrinks, becoming tough and leathery, so that the fruit may be easily hauled to the packing house, graded, and packed without injury.
Lemons, in California, are always picked when they reach a certain size (2 5-16 inches in diameter for winter and 2 1-4 inches for spring pickings) regardless of whether they are yellow or not. They are kept in the storage house from six to eight weeks according to color when picked. They turn golden yellow and shrink in size and the rind becomes tough and pliable. Those lemons which were bruised or injured in any way will have developed rot by this time and may be sorted out before packing. The pickers should be taught to avoid cutting the lemons with their clippers. They should also keep their finger nails closely trimmed. This care in picking and handling lemons is especially important, because the large winter and spring pickings often have to be held for the higher prices obtainable during hot summer weather.

THE BOTANY OF CITRUS PLANTS.

Botanists are not agreed in regard to the true relationship and proper classification of the different citrus fruits. Systematic studies of the genus Citrus have proved very perplexing. It is the desire of the author, however, to place before the orange grower a simple synopsis which may enable him to gain some idea of the citrus fruits as a group. The outline given below is not the result of independent botanical work, but simply the coordination by the author of the results of others. In the main, the work of H. W. Webber and H. H. Hume has been followed.

CONSPICUS OF THE CITRUS FRUITS.

**CITRUS**

- *trifoliata*, the deciduous orange.
- *aurantium*,
  - *bergamia*, source of oil of bergamot.
  - *sinensis*, common sweet orange of commerce.
- *vulgaris*, sour stock, Seville or Bigarade orange.
- *nobilis*, the Mandarin or kid-glove orange. Tangerine.
- *decumana*, the pomelo (grape-fruit), shaddock.
- *japonica*, kumquats.
- *medica*,
  - *genuina*, citron.
  - *limon*, sour lemon and sweet lemon.
  - *acida*, sour lime and sweet lime.
On the basis of this outline and before considering the question of what varieties to plant, let us glance from a botanical viewpoint at the citrus fruits as a whole.

_Citrus aurantium_. This species includes the group _sinensis_ or ordinary sweet oranges with which we are all familiar, such as Washington Navel, Mediterranean Sweet, etc.

_Citrus vulgaris_. This is the sour or bitter bigarade orange commonly grown as an ornamental tree in Phoenix. This may more properly be called the Seville orange.

_Citrus decumana_. Here are included the pomelos or grapefruits, the shaddock, etc. They are vigorous growing trees with very dark green leaves, very prolific in bearing.

_Citrus medica_. The citron, lemon, sour lime and sweet lime all belong to this species. They are in general far more sensitive to frost than the three preceding species.

_Citrus japonica_. This includes the kumquats or _kin kuns_, all small bushy plants from Cochin China. Fruits small with mostly acid pulp and sweet rinds, valuable for preserving.

_Citrus nobilis_. This is the Mandarin or kid-glove orange. Here belong such small, oblate, loose-skinned varieties as China, King, Dancy tangerine, and Satsuma.

_Citrus trifoliata_. This is the only deciduous orange. The fruit is not edible. It is very hardy, being used as an outdoor ornamental in the Eastern states as far north as Washington City.

In certain locations in southern Arizona climatic and other conditions permit the growing of all the above enumerated citrus fruits. The sweet oranges are, of course, the citrus fruits of most commercial importance. This is due to the very large consumption and increasing demand for oranges. While the production of oranges in California and Florida has increased by leaps and bounds within late years, still the markets seem ready to absorb additional quantities of first-class sweet oranges at remunerative prices.

**COMMERCIAL VARIETIES OF ORANGES.**

_The Washington Navel (Bahia)._ Standing alone at the head of commercial sweet oranges is the Washington Navel, or Bahia. This variety has won the title, "The King of Oranges,"
because it has good quality, it is seedless, it is very productive,
it ships well, and it has a natural trade mark or brand which
sells it at sight wherever it may be exposed for sale. The aver-
age consumer in the North was often deterred from buying
oranges by his lack of discernment between the good and the
poor. As soon as he found that the orange with the Navel was
a good orange, he more and more persistently called for that.
The navel orange has been fairly well tested in Arizona and has
shown itself worthy of occupying from one-third to one-half the
area of the citrus groves. It should be remembered, however,
that the Navel tree is more delicate in its nature than other
varieties and requires more skill in its culture. It does not seem
to be "comfortable" under Arizona conditions unless given
more care than some other varieties require. The harvest of
Navel oranges in Salt River Valley usually begins between the
first and the fifteenth of November.

Fruit large, with good color and skin of fine texture; very
juicy, with rich clear flavor and melting pulp; seedless. A
characteristic mark like an umbilicus occurs at the apical end.
Tree semi-dwarf; prolific; medium thorny and an early bearer.
Originated at Bahia, Brazil; introduced into the United States
by William Saunders at Washington, D. C., sent to California
in 1873, and came from there into Arizona about 1890.

_Valencia Late._ This orange stands perhaps second in value
to the Washington Navel for Arizona. It is very late, not
sweetening till April or May. It hangs on the trees over summer
and may be sold as an early orange during September and Octo-
ber. It has a tendency to turn green again during the summer
and sometimes gets too large and puffy. Woodpeckers are also
likely to peck them full of holes. For these reasons Valencias are
often sold to the best advantage during late May and early June.

Fruit medium to large; oblong; tapering toward calyx;
pulp very fine when fully ripe; skin smooth; flavor sub-acid.
Tree of good size, very thrifty; foliage much more healthy in
Salt River Valley than that of the Navel. An abundant bearer,
though not commencing to bear heavily until the seventh or
eighth year. Of European origin, has been grown in Cali-
fornia since 1882.
Paper Rind. A good, medium late orange.

Fruit medium in size, round; very firm; quite juicy; pale in color; very thin smooth skin; uniform in size, requiring but little grading; pulp melting; quality very good. Hangs on the trees in good condition without dropping till August. Tree semi-dwarf but a vigorous grower; foliage healthy, medium thorny; abundant bearer. Has been grown and much prized in California for more than twenty years, and is well worthy of more extensive planting in Arizona.

Other varieties of secondary importance are Mediterranean Sweet, Parson Brown, Jaffa, Ruby Blood, and Thompson's Navel.

THE POMELO.

Next in commercial importance to the orange in Arizona stands the pomelo, often called grape-fruit in the markets. As far as the growth of the trees is concerned, they succeed even better under Arizona conditions than sweet oranges. They are good shippers and hold up well on the market. The demand for grape-fruit is very small compared with the demand for oranges, yet it is usually greater than the supply and remunerative prices have been the rule. It is very probable that the demand will continue to increase as more people in the Northern and Eastern markets become acquainted with the refreshing and supposed medicinal qualities of the fruit. The pomelo is well worthy of a much more extended culture than now obtains.

*Triumph.* Form oblate, size 3 5-8 x 4 inches; color light yellow; rind smooth; sections eleven; bitter principle not strong; pulp juicy and melting; seeds about thirty-five; medium early.

Marsh (Marsh's Seedless). Form oblate roundish, size 3 1-2 x 4 3-4 inches; color pale yellow; rind smooth; sections thirteen; flesh grayish green; bitterness not strong; medium sweet; pith open; seeds often none, sometimes from two to five; season from January to March.

Duncan. Form oblate, size 4 1-4 x 5 1-4 inches; stem large; apex slightly scarred; rind medium thick, firm; sections fourteen; juice sacks large and closely packed; bitterness rather strong;

* Descriptions condensed from Hume. (Fla. Bull. 58)
acidity and sweetness good; seeds five or more; season late. The tree is especially hardy to frost.

Aurantium. Probably a hybrid between the sweet orange and the pomelo. Form oblate, size 3 1-2 x 3 7-8 inches; color light yellow; rind smooth; sections eleven, regular; flesh grayish green; bitter principle not marked; acidity medium; seeds about thirty-five; season late.

Other desirable varieties are Commercial, Pernambuco, Royal, Walters, and Excelsior.

THE LEMON.

The production of lemons in Arizona will probably not reach proportions comparable with the orange output. There are two reasons for this,—the lemon is more susceptible to injury from frost, and there is greater expense involved in providing warehouses for processing and storing the fruit. The lemon, unlike the orange, must often be stored for many months in a building where moisture and temperature conditions can be controlled. The demands of local markets, however, do not necessitate such expensive storehouses, and the acreage of lemons may therefore be safely increased till the demands of at least all Arizona markets are satisfied.

Freedom from thorns is a great advantage in a lemon variety. In a thorny tree much of the fruit is punctured when the wind moves the branches.

*Eureka. Fruit medium size; smooth, glossy rind; an excellent keeper. Acid strong and most pleasant, with very few seeds. Tree semi-dwarf; foliage sparse; nearly thornless; inclined to bear at the extremities of the branches; comes into bearing early.

Lisbon. Fruit of medium size; fine grain; sweet rind; acid strong; seeds few; an excellent keeper. Grows uniformly and ripens evenly. Tree is a strong grower; very prolific; thorny, but thorns decrease as tree grows older; comes into bearing late.

Villa Franca. Fruit oblong, slightly pointed at the blossom end; rind thin, with no bitterness; acid strong; juicy, nearly seedless. Tree almost thornless; foliage very abundant, which

* Descriptions taken from Lelong, Calif. State Board of Hort., 1902.
protects the fruit from scorching; slightly more hardy to cold than other varieties.

Other desirable varieties are Genoa, Bonnie Brae, Royal Messina, Belair, and Sicily.

VARIETIES FOR GARDENS.

The above remarks concerning varieties apply to commercial conditions. The cities of Tucson, Phoenix, and a part of Yuma, do not lie in the commercial citrus area. The residents of these towns may, however, raise good oranges and pomelos in protected situations in yards and gardens, provided a proper selection of hardy varieties and resistant stocks is made.

Almost any variety of orange may be grown as specimen trees in the above mentioned towns, if protection be given them with tent cloth on the coldest nights. In the event of a sudden and severe freeze, a lantern should be kept burning under the cloth. As the trees grow in size, making this protection more difficult, they become harder and need protection less. The pomelo makes a very attractive lawn tree when grown in this way. It requires somewhat less protection than navel oranges.

Satsuma. This orange should succeed well in gardens with no protection. It is a small, flat orange of the Mandarin type; very sweet, and of high quality; juice abundant; pulp melting; seedless. Tree thornless; a dwarf grower of spreading habit. This variety has repeatedly come through cold snaps in Florida, Texas, and California, when all other edible oranges alongside them were killed.

Kumquats. The writer is not aware that the kumquats have been tried as yet in the towns of Arizona. Judging from experience elsewhere, however, they would probably succeed in the ordinary city yard or garden. They are small trees reaching ten feet in height, very resistant to frost. The fruit is small, about one inch in diameter, with sweet, aromatic rinds. It may be eaten fresh or made into delicious preserves. Kumquats are also valuable as movable, ornamental plants, when grown in boxes or tubs. They should be secured budded on trifoliate stocks.
The *Marumi* Kumquat is most hardy to cold. It has round fruit borne in great abundance. Ripens in October. Twigs somewhat thorny.

The *Nagami* Kumquat is oblong, olive-shaped; fruit golden yellow; rind smooth, aromatic, and spicy. Tree thornless, slightly more susceptible to freezing than Marumi.

The sour orange, (Seville or Bigarade orange) is already commonly grown in Phoenix. It is ornamental and hardy. The fruit is not edible fresh, but a fine quality of marmalade may be made from it. Also a refreshing drink may be prepared by the addition of sugar.

The trifoliate orange is of value only as an ornamental and as a stock upon which to grow other varieties. It is deciduous, thorny, and very hardy, standing without any protection anywhere in Southern Arizona.

**INSECTS INJURIOUS TO CITRUS TREES.**

*Scale Insects.*

There is a very common impression among fruit growers in southern Arizona that on account of the very dry and hot summers, orange groves are in little danger from insect pests. This is only partly true. While it is true that neither the purple, the black, nor the cottony cushion scale is able to live under our climatic conditions, we still have cause to fear the red, the yellow, and the soft scales. Many ranchers and prospective investors are prone to broadly accept the assertion of real estate men and others that "orange scale" cannot exist in Arizona. They should realize that there are at least six different and distinct kinds of orange scale in California, three of which have been pretty well demonstrated not to live in our climate; while the other three are still an unknown quantity with the probability on the side of their succeeding more or less in Arizona orange groves.

The red scale, *Aspidiotus aurantii*, so far as known, has not been introduced. It is still a question as to how destructive it would prove under Arizona conditions. The writer, however, found many of the orange groves about Guaymas, Sonora, practically ruined by this scale. Also at Hermosillo, where the conditions are very much like our own, the citizens have been com-
peled to cut down and burn all the orange trees on the Capitol grounds as well as many about town, in order to bring this pest under control and prevent it from spreading into the large commercial groves near by.

The yellow scale, *Aspidiotus citrinus*, should also be kept under suspicion. It thrives at Oroville and Marysville, California, where the climate is dry and very-hot in summer.

The soft scale, *Lecanium hesperidum*, while not a very serious orange pest, oftentimes does much harm. The writer's attention was called to a Washington Navel tree in a garden near Phoenix which was literally covered with soft scales that were greatly injuring the tree. It was repeatedly sprayed, at the writer's suggestion, with a soft soap wash, and the scale was brought under control. The writer also found live soft scale on orange trees shipped into Phoenix in the spring of 1908. For these reasons it is important that planters keep a sharp lookout for this scale, and they should by all means dip their trees before planting, as explained below.

The purple scale, *Mytilaspis citricola*; the black scale, *Lecanium oleae*; and the cottony cushion scale, *Icerya purchasi*, are not able to withstand the dry hot summers of Arizona, and our citrus growers probably have nothing to fear from them. It may also be added that the absence of the black scale from our groves means the absence of the sooty mould fungus, *Meliola camelliae*, which lives on the honeydew excreted by the scale, and covers both leaves and fruit with a black sooty substance. On this account Arizona oranges and lemons are always clean and bright, and the expensive washing and brushing as practiced in humid citrus districts is not necessary.

In order to guard against the introduction of scale insects, white fly, and such pests, all citrus stock should be dipped before it is planted. The following formula, taken from Hume's book on citrus fruits is recommended:

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Resin............................................. 30 pounds.
Caustic soda (98 per cent)................. 8 pounds.
Fish oil........................................ 4 1-2 pints.
Water, to make................................100 gallons.
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"Place the resin (well broken up), caustic soda and fish oil in a large iron kettle. Pour over them twenty gallons of water, and cook
well over a good fire for not less than three hours. Then add hot water a little at a time, and stir thoroughly until the amount of the solution reaches one hundred gallons. After this has cooled the young trees should be dipped so that all parts except the roots bear an even coating of the mixture."

Experienced growers claim that it pays to dip trees even though there be no scale to guard against. They say that the coating on the leaves and stems retards evaporation and in some way protects the transplanted tree, thus encouraging a quick start into growth.

**Thrips.**

By far the most serious enemy of citrus trees at the present time in the arid Southwest is a species of thrips. Specimens collected by the writer at Phoenix were sent to Dr. W. E. Hinds of Auburn, Alabama, and from the limited material he tentatively identified the species as *Euthrips occidentalis* (Pergandi). These thrips are injurious to citrus trees only in hot dry countries and are becoming quite serious at Hermosillo, Sonora, and in the San Joaquin Valley of California, as well as in Salt River Val-

![Image of orange leaves injured by thrips compared with healthy leaf]
ley. Thrips are very minute, and keep themselves so well concealed in the growing bud that but few orchardists realize that they are the cause of a serious leaf disease. These insects infest the growing shoots of the orange. Their mouth parts are fitted both for sucking and for scraping or rasping the surface of the very tender leaves. They force their way into the terminal bud where they conceal themselves in the very small and as yet unopened leaves, which they injure seriously by sucking and rasping the tender surfaces. Later, as the shoot elongates and the mutilated leaves unfold, they are distorted, thickened, and permanently much reduced in size, with characteristic whitish markings. Affected leaves never turn yellow and fall, but on account of their being so distorted and reduced in size, the twigs are not properly nourished and consequently enter the winter dormant period in a weakened condition. They often die back before spring, when a bunch of small shoots pushes out to take their place. These in turn are attacked by thrips, and the result is a ragged tree with bunchy, unhealthy foliage. Since this imperfect cover fails to afford good shade the larger limbs and trunk of the tree are soon seriously sunburned.

After a very careful survey of the trouble in Salt River Valley, it was found that all varieties are not equally susceptible
to thrips injury. The Washington Navel seems to be much more susceptible than any other variety observed. Valencia Late is attacked to a less degree than the Navel." Paper Rind

![Image of oranges with sunburn and thrips injury]

Fig. 8. Sunburn of the orange, distinct in appearance from thrips injury.

St. Michael seems to be almost free from it, though the trees observed occurred in the same grove with very badly infested Navels. Lemons are only slightly attacked, and pomelos seem to be practically free from the trouble. When thrips enter the blossom buds of the orange just as they are opening, they rasp and scrape the surface of the ovary in such a way as to cause injury to the tender skin. After the petals fall and the orange grows in size, the injured skin expands and permanent scars appear which, while they in no way lessen the eating qualities of the fruit, detract seriously from its looks and selling value. In some years the weather conditions during blooming time are more favorable to the thrips than in others, and hence the amount of "rind-scar" noticed at the packing house is greater.

At present little is known about the life history of this orange thrips, and no remedial measures have as yet been marked out. The writer plans to experiment along this line in the future.
Sucking Bug.

Within the last few years a large sucking bug, *Leptoglossus zonatus*, known in Sonora as the "Chincha," has become established in Salt River Valley and is doing much damage in the orange groves. This bug is about three-fourths of an inch long and gray in color. Its two large hind legs are flattened out into a wide, toothed flange which is very characteristic. There are two white spots on the back and two on the thorax. The mouth parts include a long tube which is used for sucking. This is usually carried folded back against the abdomen. When molested, these bugs excrete a dark liquid with the very disagreeable odor so characteristic of the stink-bug family. This insect breeds in great numbers on pomegranate bushes. They begin to lay their eggs about the middle of June. Pomegranates which are split open are usually selected, as the young receive greater protection, and also are able to puncture the juice sacks with greater ease. The young are red in color and are wingless. They grow rapidly, going through several moults, and are full grown in about four weeks. Egg laying seems to continue from about the middle of June until October. These bugs suck other fruits besides pomegranates, and about the first of September they go to the orange trees, if any are near by. At this time the oranges are about three-fourths grown and perfectly green. The insects puncture the rind of the orange and suck the juice from the pulp beneath with deleterious effects, the character and extent of which are now under investigation.

No remedy for this insect can as yet be given, except to hand-pick into buckets of water containing a little kerosene, in the early morning. At this time the insects are sluggish; while during the heat of the day they are very active and difficult to capture. It is also suggested that pomegranates be not used as windbreaks, or otherwise planted near orange groves, as they seem to be the favorite breeding places for these insects.

The White Fly.

The white fly, *Alerodes citri*, has never so far as we know been introduced into Arizona. It is one of the most dreaded citrus pests of Florida. It probably would not succeed in Salt River Valley; yet it has caused much trouble at Oroville.
and Marysville, California, where the climatic conditions approximate our own. This insect appears as a very small white fly and feeds on the under sides of the leaves. It is transported from place to place on the leaves of nursery stock. By avoiding Florida stock and by conscientious dipping we may escape giving this insect a trial in our citrus groves.

Other Insects.

There are a number of other insects which have been observed, at different seasons of the year, to chew or suck the leaves of orange trees. Among those noted by the writer and others* in Salt River Valley are aphids, which attack the young growth in the spring, angular-winged katydids, several species of grasshoppers, a tree cricket, the green alfalfa-hopper, and an orange worm.

DISEASES OF CITRUS TREES.

Gummosis.

This trouble is also known as gum disease. While it occurs in all citrus regions, it is not at the present time very serious in Salt River Valley. This disease is very destructive at Herrerosillo, Sonora, where the climatic conditions approximate those in southern Arizona; hence it is not safe to assume that it will not become serious with us. The true cause of the trouble is not known. It seems to be favored by unsanitary soil conditions close around the tree, such as too much water or water standing against the trunk. If the soil is in poor physical condition from any cause, gum disease often follows. It is first recognized by an excretion of gum oozing out near the ground. Later the bark about the gummed area dries up and falls away in large pieces. If the bare areas encircle the tree it will certainly die and may as well be removed at once. If it extends only part way around, the tree may be treated to advantage as follows: Prune away the lower limbs so the air can circulate well under the tree and draw the soil away from the crown to the depth of three or four inches. Then cut away all of the diseased bark, being careful to burn all fragments because of the possibility of infection therefrom. The tree should be left in this condition

*Cockerell Ariz. Sta Bull 32, 1899
three or four days and then revisited. If more gum is oozing out, more cutting should be done, and so on till the gum ceases to flow. Then paint the whole cut area with plain melted beeswax. Soon the injured part will heal over with a formation of new bark, and, provided the conditions which caused the gumming are looked after and improved, the tree may fully recover. If not, the gum disease will likely recur the following spring.

Not all citrus fruits are subject to gum disease. For remarks on resistance, see page 303

*Scaly Bark.*

This disease is very distinct from gummosis. It is always found on the trunk and large upper branches. There is a smaller exudation of gum, and the bark in drying scales off in much smaller pieces. This trouble is hardly as serious as gummosis, but if left alone will destroy the symmetry of the tree. One of the best treatments is to thoroughly scrape all loose bark from the affected parts, and then paint with a solution made by dissolving six pounds of caustic soda in twenty-five gallons of

*The terms gummosis, foot-rot, mal-di-goma, gum disease, and scaly bark are often used indiscriminately for two apparently distinct diseases.
This formula is strongly recommended by Mr. William Wood of Whittier, California, who has had much experience in its use.

**Black Rot of the Navel.**

This disease is caused by a fungus which was named and described as *Alternaria citri* by N. B. Pierce [Bot. Gaz. 33 (1902), No. 3, pp. 234, 235]. The annual losses in Arizona Navel groves due to this cause are estimated at from two to five per cent. The disease attacks only Navel oranges, and may be recognized by the premature ripening, abnormally large size, and very deep red color. These affected fruits are very conspicuous on the trees before the main crop has colored up. The spores of the fungus gain entrance at the navel end through slight imperfections of the peel, and produce a decayed area under the skin. All diseased fruits should be carefully gathered up and either burned or deeply buried.

**Yellows, and Other Troubles.**

The disease known as yellows is not at present understood. It is thought to be a physiological trouble of some sort. Usually the foliage on certain limbs of a tree will turn bright yellow, and where this occurs it generally gives the grove a sickly appearance. Groves which are given the best of care are rarely troubled with yellows. Moderate applications of a commercial fertilizer containing high percentages of organic matter and nitrogen, and medium amounts of phosphoric acid, have in the past been recommended by the Director of this Station.

During some years a small percentage of the oranges crack open, thus admitting insects, especially the vinegar fly (*Drosophila amephiloda*), which, by inoculating the fruit with bacteria and moulds, soon accomplishes their decay. It is probable that this is caused by irregular irrigation, and that it is likely to be less severe in the future than it has been in the past.

**Die-back** is a serious disease in Florida, but with the exception of a single tree it is not known in Arizona. The writer's attention was called to this tree, a Jaffa near Phoenix, in the fall of 1907, and after a careful examination it proved to be a typical, though temporary, case of die-back.
The Arizona orange grower finds it necessary to keep a sharp lookout for gophers. These must be trapped or they will injure the trees by eating away the bark at the surface of the ground. The Red Shafted Flicker also does some damage by pecking holes in the fruit. This is especially noticeable in groves which are near the desert, where these birds nest in the giant cactus.

CROP-PEST INSPECTION LAWS.

The danger of the spread of insect pests and contagious diseases from one part of the country to another by means of nursery stock is very great. Many of the most destructive insects of the United States have been disseminated in this way. Most of the states have inspection laws which compel the thorough inspection of all nurseries within the state, and also require such shipments of nursery stock as come into the state to bear a certificate of inspection. In this way a great deal has been done toward keeping crop pests confined to the areas formerly infested. Arizona has no such law except in the case of date palms and their offshoots.

This is very deplorable in view of the great danger Arizona fruit growers are subjected to. The fumigation of citrus trees is expensive, and if recourse to spraying or fumigation becomes necessary the profits from Arizona orchards will be materially lowered. If citrus culture in Arizona is to be maintained in its present state of partial freedom from injurious insects, it is imperative that suitable inspection laws be passed as soon as possible. These laws should be made to apply to all injurious insects and contagious diseases, but they should be especially stringent in regard to red scale, soft scale, white fly, grape phylloxera, crown gall, and the Morelos orange worm of Mexico.

Should a grower discover some unfamiliar insect or disease which is damaging his trees, he owes it to his neighbor as well to as himself to communicate at once with his Experiment Station. He should give full information in regard to the infestation, and send specimens whenever possible.
PRODUCTION AND DEMAND.

The quantity of citrus fruits produced at present in Arizona, while of considerable importance to Phoenix and Yuma, is yet so small when compared with the immense amounts produced in California and Florida as to be quite negligible. For the season of 1907-1908 Arizona produced somewhat less than 150 cars. About 110 cars of this were packed and sold through the Arizona Orange Growers' Association of Phoenix. The same season California produced upwards of 30,000 cars. It will be seen from this that the citrus industry of Arizona has considerable room to expand before it will itself be responsible for overstocked markets. But even with the enormous production of citrus fruits within the United States, the demand is such that we still import considerable quantities. In spite of the heavy duty of one cent per pound, this country last year imported $4,607,791.00 worth of oranges and lemons. These came from twenty-one different countries, but chiefly from Italy, Mexico, and the British West Indies. Oranges and lemons were imported from Mexico in 1907 to the value of $47,496.00. Of this amount only $8,984.00 came through Arizona ports. In this connection it may be of interest to give briefly the status of the citrus industry in the State of Sonora, Mexico:

The State of Sonora, when considered in the light of its climate, soil, flora, and water supply, belongs to the same horticultural district as Arizona; hence the two areas have much in common. The country around Hermosillo especially has a climate very much like that of the Salt River Valley.

Citrus fruits are grown commercially only along the railroad. Orchards are found from Pierson and Magdalena, at an elevation of 2,600 and 2,460 feet respectively, down to Guaymas at sea level. The principal groves are at Hermosillo, which has an elevation of 693 feet. The country is typical desert, the rainfall varying from three to ten inches. The orange groves at Hermosillo are irrigated with water from the Sonora River. At Guaymas the water is pumped from wells. There are, roughly estimated, about 500 acres of commercial orange groves in Sonora, mostly of the Sweet Seedling varieties. The groves near Guaymas are so badly infested with red scale that the
fruit is disposed of locally. At Hermosillo there are several packing sheds and the fruit is sold abroad, supplying an early market. In the season of 1907-8, about 250 cars were sent in bond through the United States to Canada, which they enter duty free. During Christmas week about twenty-five cars were marketed in the United States. Laborers are paid from ten to fifteen dollars a month in addition to board and keep. Box shooks are bought cheaply in Oregon and brought to Guaymas by boat, duty free.

There are several thousand acres of good citrus lands near Hermosillo, with water, which might be profitably planted to oranges if a market were available.

SUMMARY.

Citrus fruits have been grown in Arizona for the past fifteen years, and in Sonora for a much longer period, at a variable profit.

At present less than fifteen hundred acres in the arid Southwest are occupied by citrus groves. The three principal areas are Salt River Valley, the mesa near Yuma, and the Sonora Valley near Hermosillo. This area may be increased possibly to 15,000 acres or more when the U. S. Reclamation Service projects upon which the two former areas are dependent are completed.

The Washington Navel orange ripens early, and this, together with its freedom from smut and its fine color, gives it a ready sale at high prices.

The chief need in connection with soil management is an increase in the humus content. This is to be brought about chiefly by growing and turning under green cover crops.

The old idea that citrus culture in Arizona is not endangered by insect pests or plant diseases should be considerably modified, as several such insects and plant diseases are already known.

Every care should be exercised by all concerned to prevent the introduction of injurious insects and diseases on the citrus stock which will be brought in as the industry grows. Each tree should be dipped before being planted. Should such pests be discovered, the Experiment Station should be notified.