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RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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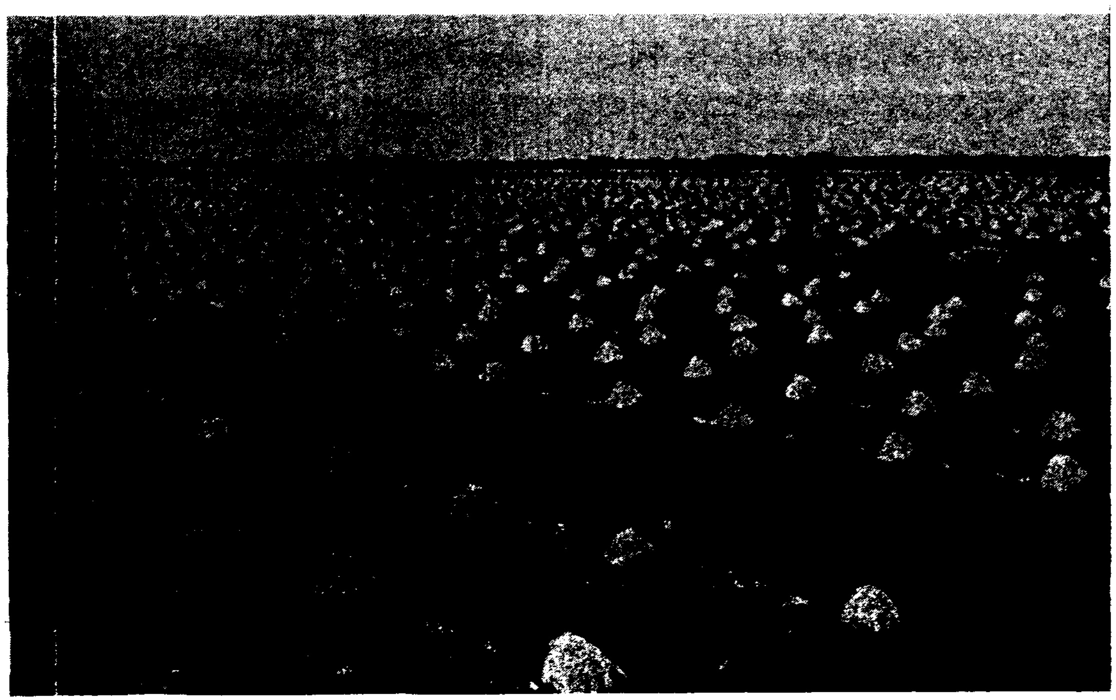

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RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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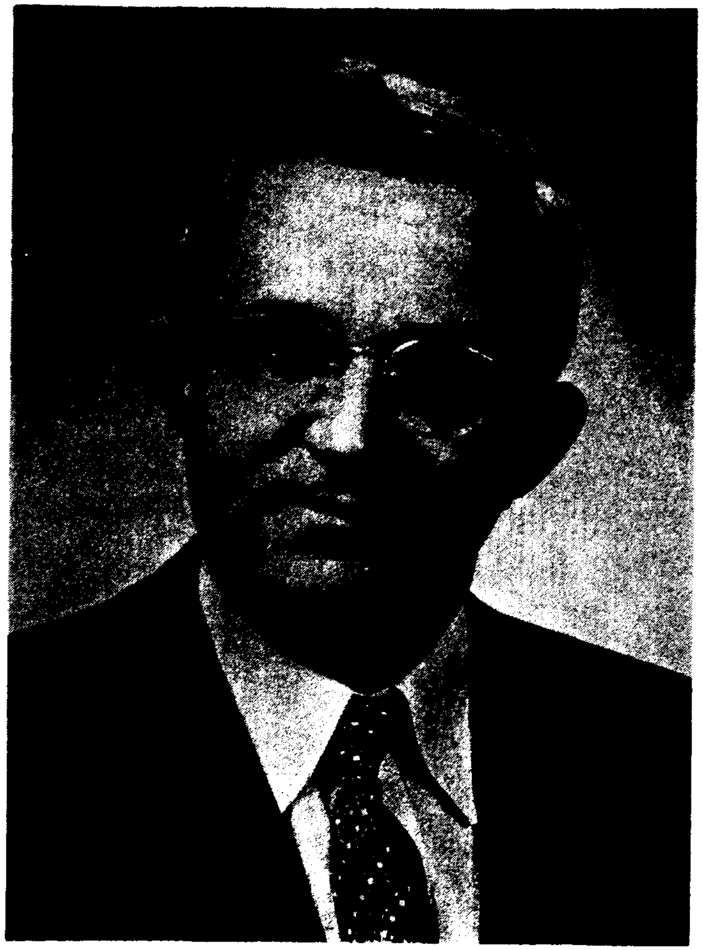

Dr. George Schulz, President

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1956-1957

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Water—Its Uses and Effects on Valley Soils

Dr. George Schulz, *President*
Rio Grande Valley Horticultural Society

Agriculture is still the number ONE problem of the Valley. The progress of our Valley is closely linked to the progress of our horticultural enterprise. Business, finance, and everyone's well being depend upon the efficiency in which we make use of our land.

There are many problems on the road to a better horticultural enterprise; Freezes, storms, drought, inefficient crop management, adherence to inflexible patterns instead of intelligent adjustment to the ways of nature.

Fortunately we live in the age of science and technology. Our Valley's agriculture can gain much from the tremendous developments in the field of science, from the work of highly trained specialists. Advancement of knowledge is not enough. Knowledge must be interpreted into the language of the grower so that his work may benefit.

It is, therefore, the principle behind the efforts of the Valley Horticultural Society to bring together growers as well as men of research and men of industry in a free and stimulating exchange of thought.

In the Horticultural history of the Valley, the last year will not be forgotten. It was the year of our lowest rainfall in history, the year when tne river went dry for a long time. It seems to be characteristic for this area that, whenever we think, we have a "Magic Valley," something happens, which makes us realize that only with foresight and understanding will we be able to recreate this "Magic Valley." In other words, the Valley is only as magic as we make it.

What originally attracted people to this region was a warm climate, a fertile soil, and a river filled with water. One simply had to pump the water on the land and then watch crops grow. Water was good, more water would be better, but—something went wrong. Gradually, people began to realize that things were not so simple; that crop growth, soil fertility, and irrigation water are something closely related, and that the principles governing this relationship must be understood in order to succeed.

The soil at the beginning of the age of general irrigation was of ideal structural condition—open, porous, well aerated, able to absorb and offer to crops a maximum reservoir of moisture.

Ideal irrigation consists in replacing the amount of water which has been absorbed by the crops before the wilting point is reached—no more, no less. Immediately after an irrigation, the soil holds all the moisture it can possibly hold against the pull of gravity. Soil moisture is at field capacity. At any available moisture percentage between field capacity and the permanent wilting point, crops are able to absorb moisture with approximately the same ease. We, therefore, do not give our crops a special break by keeping soil moisture at a high level or by continuously giving more water than taken out. To disregard these important facts is not only a waste of water, it also causes serious trouble. This is especially the case in our Valley because soils become heavier in lower layers.

Many farmers applied water too frequently in too heavy amounts. This resulted in a deterioration of the formerly open and porous structure of the soil. The soil became tight and puddled, a less effective reservoir of available moisture. Lower root growth suffered. Roots need air as well as water. In many orchards, the treetops kept on growing while root growth came to a standstill because of water-logged soil layers. More or less temporary water tables developed. The soil stayed wet to the surface for prolonged periods. Here on the surface, water evaporated in excessive amounts and salts concentrated.

Only gradually did the Valley become conscious of these problems. Drainage systems were installed to facilitate wash-down of salts and to bring about improved soil aeration. A considerable acreage was leveled to avoid accumulation of excess moisture in low areas and to permit a uniform distribution of irrigation water and rain. Yet, much remained to be done, much had to be learned to use irrigation water effectively and to keep the soil in perfect state of fertility.

Then events took an unexpected turn. The beginning of June, 1956, the gates of Falcon Dam closed. There was no more irrigation water from the river and there was no more rain for the rest of the year. During the following hot weeks and months, the Valley land went dry fast—first in the surface, then in deeper and deeper layers.

As the drought went on, the results from formerly unwise irrigation practices became most evident. Where the soil was tight, where roots were shallow, and where salts were excessive, crops wilted first. The picture was especially interesting in our orchards. Old trees, hit severely by the '51 freeze, deteriorated rapidly. The soil moisture stress plus serious damage of the moisture leading tissues of trunks and branches was too much. Many of these trees died. In orchards with no available water of any kind, fruit sizes stayed small, making the grower realize the great importance of water in raising quality fruit. Formerly good orchards showed areas of poor condition. Closer investigation showed that deeper layers in these areas either were excessively tight or showed high salts.

On the other hand, many growers were surprised to notice how long trees were able to stand up with no irrigation or rain. The deep roots in open salt-free soil profiles benefitted greatly from subsoil moisture. This moisture from below kept tree tops as well as roots in upper dry soil layers alive. It was demonstrated to the grower that trees growing under proper profile conditions were able to survive prolonged drought periods. This is the reason why considerable new citrus plantings were planned in spite of the drought.

The growing of covercrops was temporarily abandoned in most orchards because transpiring covercrops would compete with the trees for soil moisture. Young trees were kept alive by tank watering.

The important question of the day became the subterranean water reservoir of the Valley. Wells were drilled in all parts to varying depth. The problem, of course, was the quality of the water for irrigation purposes.

There are wells producing water suitable for permanent irrigation (located mainly along the Rio Grande River). On the other hand, there are types of water of such poor quality that two or three irrigations would kill a crop. Such water is not suitable. In between are the many different types of water which would not be suitable for permanent irrigation (with this water as sole source). Such waters may, however, become valuable in times of emergency. There are good emergency waters, mediocre emergency waters, and poor emergency waters (only to be used in utter emergency to save a crop).

There are a number of misconceptions among farmers in connection with the use of poor quality water. Some start to use such water, see no injury and thus disregard any consideration of water quality. Others use soil amendments on fields with injured crops, thinking that this will make salts unavailable.

It should be understood that water of doubtful quality often may be used for a number of times without injury. Each time the water is applied, salts will increase somewhat in the soil until finally the critical point of crop damage is reached. The time for such damage to occur depends upon how much salt there is in the soil to begin with, how bad the water is, how hot the weather is (accelerated evaporation) and upon the method of applying the water.

In regard to using soil amending materials, there are no materials which can be practically used to tie up salts, making them ineffective. Soil amendments are used in case the water is of high Sodium ratio. When such water contacts the soil, the clay particles of the soil absorb Sodium. This will cause them to swell up, making the soil poorly permeable and hard (crusty when dry). This will result in slow drainage, increased surface evaporation, poor aeration, and retarded root growth. To counteract this Sodium effect, Sodium must be replaced by Calcium. Gypsum is used as a source of available Calcium. Sulfur and Acids are used to make calcium available from the natural supply of calcium in the soil (which is generally of low availability).

Aside from the tota salts and Sodium ratio, growers have been interested in the Boron content of the water. A certain percentage of our wells show high or even very high Boron. Caution is needed, especially on citrus and particularly if the water is sprinkled on the foliage.

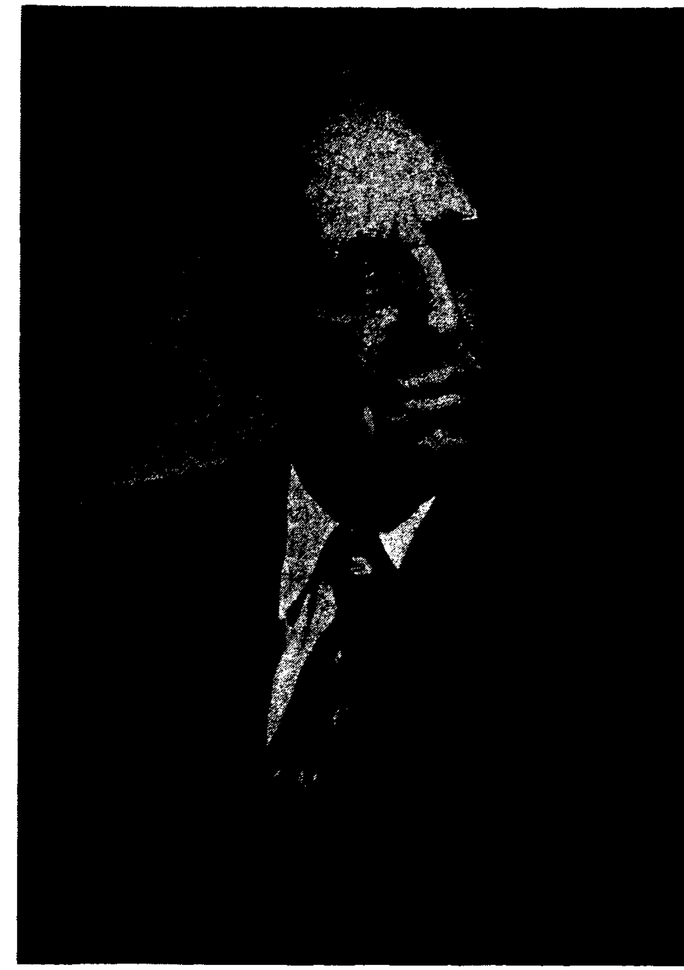
It cannot be emphasized enough that the successful use of emergency waters during periods of waterstress depends upon the method in which it is applied. How good is the water, is one question—what can be done with it, how to use it, is another question. Land can be damaged by improper use of good irrigation water. On the other hand, relatively poor water, used in the proper manner, may serve a useful purpose. Understanding of all factors concerned is basic to permanent agriculture. In this respect, row cropping offers a number of relatively serious problems.

Water rises rapidly from furrows into raised planting beds. It takes relatively much water to keep the upper inches of the bed sufficiently moist to germinate seed and to keep young plants going. Frequent waterings, before the bulk of the soil has had a chance to dry, tend to compact the soil and reduce permeability. Farmers soon began to realize the special importance of water quality on row crops. They noticed that the problem of salt concentrations was especially serious during periods of hot weather. They generally used shallower planting beds. They experimented with planting beds of different shape, avoiding crops to grow on the highest points of the beds where salts were most concentrated. They realized more and more the disadvantages of continuous row cropping. The idea of crop rotation and its benefits to soil fertility became more popular.

Viewing the events of the past few months, there has, no doubt, been much bitter disappointment. On the other hand, we have learned a lot. It seems as if we are entering a new era characterized by a more sensible and more orderly use of our water resources, a more effective use of the water on the land, an improved fertility of the soil, and a more efficient Valley agriculture.

We are inclined to be over-optimistic when everything goes right—to go down into deep pessimism when things go wrong. To brag about what is given to us, is one thing—to do something about it, is something else. No area is without its problems. The important thing is, how we face these problems—whether we go to sleep and ignore them or whether we face them for what they are worth, wrestle with them and try to solve them.

In the last analysis, the attitude towards problems depends upon the people—upon individuals who show concern for their work, deep understanding for nature, and an unbiased devotion to truth. It all depends upon individuals, who, with an ever open mind are eager to learn.



E. M. Goodwin

E. M. Goodwin
Recipient of The Arthur T. Potts Award
January 21, 1957

Every year the Rio Grande Valley Horticultural Society recognizes one person for his outstanding work in the field of horticulture in this area.

Nothing could be more symbolic for the accomplishments in any field than to honor the life's work of a prominent person. All accomplishments finally go back to the creative minds of free men. What the world needs more than anything else are men of integrity who have faith in their work, who are proud of the craftsmanship of their accomplishments.

The first award of the Horticultural Society went to Arthur T. Potts, the pioneer in the field of citrus long before citrus became an established industry in the Valley. The award bears his name.

Last year's Arthur T. Pott's award went to Dr. Wilson Popenoe. His work has been of greatest benefit to our Valley horticulture.

This year's award goes to a prominent and colorful figure, well known to almost all of you, Mr. E. M. Goodwin of Mission.

We all know that he is the developer of the beautiful Goodwin Tract, but there is much more to his horticultural foresighted accomplishments. Mr. Goodwin built the first all concrete-lined irrigation system, new at that time. Mr. Goodwin was one of the first growers to advocate discontinuation of clean cultivation—conscious of the role of organic matter in the soil. He engaged in large scale and successful experiments in tree pruning. The low citrus price problem accupied his mind incessantly and he became a front fighter for better marketing conditions for our citrus. He believed in extending the marketing season over many months instead of swamping the market all at once.

These are only a few headlines out of the life of this active Valley personality. Whenever something happens in the Valley's horticulture, one can be sure to hear the voice of E. M. Goodwin—at times very emphatically. Mr. Goodwin is a man of high integrity, of dynamic foresight, of keenest interest, and of great enthusiasm.

It is an honor to present in the name of the Valley Horticultural Society the 1957 Arthur T. Pott's award to Mr. E. M. Goodwin of Mission, Texas.

Program of the Eleventh Annual Institute

of the

Rio Grande Valley Horticultural Society

Tuesday, Jan. 22, 1957

Valley Citrus Center of Texas A. and I. College

Mile 3 West, Mile 7¾ North, Weslaco, Texas

Special Horticultural Exhibits in Main Building

OPENING SESSION — 9:00 A. M.

Chairman: AUSTIN ANSON, Mgr.
Texas Citrus & Vegetable Growers & Shippers

Report of the President .... Dr. George R. Schulz

Current Water Problems: .... Col. Kenneth M. Smith
Special Watermaster Falcon Water Compact

What to Expect from Citrus Research .... Dr. A. M. Boyce
Director Citrus Experiment Station Riverside, California

Recess 10:30 — 10:45 A. M.

SECOND SESSION

Chairman: SANLEY B. CROCKETT
Harlingen, Texas

Subtropical Fruit Culture .... Dr. Wilson Popenoe
Director Escuela Agricola Panamericana, Tegucigalpa, Honduras

Fruit and Vegetable Research: .... Dr. Frank Cullinan
Chief Horticultural Crops Research Branch, Beltsville, Maryland

NOON — BARBECUE

THIRD SESSION — 1:30 P. M.

Chairman: DR. R. D. LEWIS
Director Texas Agricultural Exp. Station, College Station, Texas

Arthur T. Potts Award Presentation: .... By Dr. George R. Schulz, Pres.

Soil Moisture in Relation to Plant Growth: .... Dr. C. H. Wadleigh
Chief Land Management Branch
Agricultural Research Service, Beltsville, Md.

Survey of Avocado Insects: .... D. L. Bush
Entomologist Mexican Fruit Fly Research
U. S. Dept. of Agr. Mexico City, Mexico

Recess — 2:30 — 2:40 P. M.

SPLIT SESSION

Citrus Panel: .... Production of High Quality Citrus Fruit

Chairman: WILLIAM HUGHES
Elsa, Texas

Panel Members: Dr A. M. Boyce, California Citrus Exp. Station
Dr. R. H. Cintron, Hoblitzelle Ranch, Mercedes
Dr. Wm. C. Cooper, U. S. Dept. of Agr., Weslaco
Dr. P. W. Rohrbaugh, Texas A.&I. College, Weslaco
Dr. George R. Schulz, McAllen, Texas
Herbert A. Dean, Sub-station No. 15, Weslaco
Norman P. Maxwell, Sub-station No. 15, Weslaco
Lorne S. Hamme, Texsun Citrus Exchange, Weslaco

Vegetable Panel: .... Improvement of Valley Vegetable Crops

Chairman: BOB ALLEN
Raymondville, Texas

Panel Members: Raymond Cowley, Supt., Sub-station No. 15
Texas Exp. Station, Weslaco
Dr. Bruce A. Perry, Sub-station No. 19, Winter Haven
Dr. A. L. Harrison, Plant Disease Lab., Yoakum
Dr. G. H. Godfrey, Sub-station No. 15
Paul Leeper, Sub-station No. 15
R. T. Correa, Sub-station No. 15
Frank Schuster, San Juan, Texas

AIMS AND OBJECTS

of the Lower Rio Grande Valley Horticultural Society

The purpose of the Rio Grande Horticultural Society is the advancement and development of horticulture from a scientific and practical standpoint in the lower Rio Grande Valley. It is the aim of the society to stimulate interests in all phases of Valley horticulture, to encourage research and exchange of thoughts between research workers, growers and canners.

At monthly meetings, subjects of interest are presented by specialists in their fields. These presentations are followed by open forums.

The society's annual institute is an event in the horticultural enterprise of the Valley. Outstanding speakers from all parts of the country are secured. Panel discussions, exhibits and social get-togethers round up the all-day program.

The journal of the Horticultural Society is the Society's official publication. It contains the proceedings of the annual institute and many other valuable articles of interest to Valley growers.

The monthly horticultural society news announces and discusses the monthly programs and brings other news of interest to the members of the society.

Anyone interested may become a member of the society. The annual fee is $4.00, which includes the journal.

CITRUS SECTION

J. S. Sanders, *Section Chairman*

Periodicity of Growth and Dormancy in Citrus – A Review with Some Observations of Conditions In the Lower Rio Grande Valley of Texas

William C. Cooper, *U. S. Department of Agriculture and Texas Agricultural Experiment Station, Weslaco, Texas*

Cold hardiness of citrus in the Rio Grande Valley is intimately associated with dormancy during the winter (Cooper et al, 1954, 1955). To obtain a better understanding of cold hardiness it is, therefore, necessary to investigate the nature of dormancy in citrus and to explore means of controlling it. As a preliminary to a proposed study of dormancy in citrus a review of the literature dealing with various aspects of growth and dormancy in citrus is reported herein.

There is no agreement on the use of the term "dormancy." Chandler (1913) applied it to a state of outward inactivity in which buds did not elongate unless first exposed to low temperature. Dormancy of this type is common in deciduous trees during the winter in the temperate zone. Trees with dormant buds may also have dormant cambiums. A cold treatment of the buds, however, breaks dormancy in the whole tree (Howard, 1910).

There is no evidence of dormancy of this type in citrus. In the present review the word dormancy is applied to any growth inactivity. It includes cessation of extension growth in shoots growing intermittently under favorable conditions. In other cases cessation of extension growth of shoots, usually accompanied by cessation of growth of roots and cambium, is associated with drought or cold weather, and growth begins again as soon as conditions become favorable.

EXTENSION GROWTH OF SHOOTS

Extension growth in shoots of citrus results from a series of growth flushes from false terminal buds (Schroeder, 1951). Elongation of the bud starts at a slow rate, gradually increases, then slows down, and stops; the terminal growing point dries up and abscises. Following cessation of length growth, the new leaves and buds on the shoot mature and a dormant period ensues for a week to several months, the period depending on the season of year, temperature and soil moisture. Extension growth of the shoot is resumed only when one or more lateral buds, close to the terminal, give rise to new shoots which continue to elongate, resulting in another flush of growth. A slight swelling of the stem and the presence of rings of corky material, clearly mark the dormant periods separating the growth cycles (Schroeder, 1951).

All shoots on a tree do not necessarily elongate at the same time. Extension growth may occur on a given shoot in three different growth cycles, or possibly in two, or only in one. Occasionally a shoot will not increase in length during the year. Thus the age and maturity of terminal shoots of a tree going into the winter dormant period may vary considerably and it is impossible to distinguish one from the other without tagging the shoots at the time the new flush begins.

In California the first and major growth cycle usually starts in late February or early March; a second comes in the later part of June and a third comes in the fall (Reed and MacDougal, 1938; Cameron and Schroeder, 1951; Schneider, 1952). There is usually no growth in length of shoots during late spring, late summer and winter. A similar periodicity of shoot growth is confirmed for citrus in Arizona (Crider, 1927), Florida (Smith[1]), Palestine (Cossman, 1940), and South Africa (Marloth, 1948). However, soil moisture and temperature tend to modify or interplay in controlling the time and intensity of shoot growth in some of these regions. In Palestine and South Africa a fourth growth cycle occasionally occurs in midwinter if warm weather prevails. In the Rio Grande Valley, if there are ample soil moisture and warm winter weather, there are usually four or more growth cycles a year, the number and time of the cycles depending on environmental conditions.

In summary, extension growth of shoots of citrus trees is generally intermittent. Some of the growth interruptions are induced by drought and by low temperatures, but probably three or more occur naturally even if ideal conditions for growth prevail. This statement about intermittent growth applies to trees more than one year old. Sometimes budlings will grow continuously from spring to fall.

RADIAL GROWTH

Radial growth of shoots, branches, trunks and roots of the tree is caused by cambial activity. However, both cambial activity and changes in water tension within the tree will cause changes in the diameter of the tree. Water on the outside of trunks is said to cause swelling (Lodewick, 1928). Shrinkage in the trunks of grapefruit and orange trees at Indio and Pomona, California, has also been found to accompany dormancy (Furr[2]).

A sensitive method of determining changes in trunk diameter is by the use of the dendrometer (MacDougal, 1936). The method, however, measures only a small point on the tree while cambial activity may be irregular around the citrus tree (Chandler, 1950). Using the dendrometer, Reed and MacDougal (1938), at Riverside, California, found a tendency towards alternation of extension growth in shoots and radial growth in the trunks of Washington Navel orange trees, but this alternation is far from clear cut. A major cycle of radial growth of the trunk follows the first cycle of extension growth of the shoots, while second and third cycles of radial growth come close together near the end of the second cycle of extension growth of the shoots. They found no radial growth

[1] Smith, P. F., 1956. Personal correspondence.

[2] Furr, J. R., 1956. Personal correspondence.

of trunks or extension growth of shoots of 6-year-old Washington Navel orange trees during the winter.

Schneider (1952), at Riverside, California, using circumference measurements of the trunk made with a steel tape, found no evidence of alternation of extension growth of shoots and radial growth of trunks of 30-year-old Valencia orange trees. Radial growth was found to begin in early May and continue at a rate of about 0.3 mm. in circumference per 10-day period through July 18, after which a slower erratic growth occurs until growth stops in late October.

Anatomical studies of the cambium of citrus with relation to extension growth of shoots and radial growth of trunks have been made by workers in California (Cameron and Schroeder, 1945; Schneider, 1952). Cameron and Schroeder found that cambial activity in 8-year-old Valencia orange trees at Los Angeles, California, is first evident in twigs and small branches bearing the new growth; initiation of cambial activity in other parts of the tree is very irregular, but appears to progress basipetally to the trunk of the tree. They reported that by the middle of April cambial activity was general throughout the top of the tree; it ceases in the shoots about the middle of May, in the branches in midsummer and in the trunk in December.

The studies of Schneider (1952) with 30-year-old Valencia orange trees at Riverside, California, indicate that the cambium of the trunk is dormant from about October to May. The dormant cambium consists of a zone of undifferentiated cells several layers wide between the bark and the wood. Schneider reported that bark slippage may occur at times during the dormant period and the bark breaks loose either from the face of the lignified wood, from the face of the phloem, or at various places in the cambial zone. When cambial activity begins in early May bark slippage is entirely in the initiating layer of cells at the middle of the cambial zone. After new xylem is produced bark slippage occurs either in the cambium cells or in the new xylem cells. Schneider concluded that the occurrence of bark slippage through the initiating cells of the cambium or through the new xylem cells, with no tearing of the cambial zone from the face of the phlem or mature xylem, seems to be the best indicator of current growth.

In the Rio Grande Valley of Texas free slippage of the bark of all parts of the top of bearing grapefruit trees generally occurs all year long provided ample soil moisture is available. There is no cessation of bark slipping during the winter, but it slips slightly less freely during December and January, when the buds are dormant, than in February and March immediately following the spring flush of extension growth of shoots (Cooper et al, 1955). Measurements of circumference of the trunk of 3- and 10-year-old grapefruit trees supplied with ample soil moisture were made at weekly intervals during December, 1956, and January, 1957. The bark slipped freely on all trees but there was no increase in circumference of the 10-year-old trees while the 3-year-old trees showed a rate of increase of approximately 1 mm per week.

At the time of the spring flush of grapefruit trees in the Rio Grande Valley there are a swelling of and an increase in the water content of the cambial cells. Drought, however, may completely inhibit cambial activity in all parts of the tree at any time of the year incuding the spring (Cooper et al, 1955).

The work of Roy and Gardner (1946) with Valencia orange trees grown in sand culture at Orlando, Florida, is pertinent to this review. Two-year-old trees fed continuously with a complete nutrient solution showed a steady increase in trunk circumference throughout the whole year including December and January. Very little trunk growth occurred during the winter months in intermittently-fed trees. The mean minimum air temperature during this period was approximately 52°F.

Since varying patterns of radial growth activity were observed by various workers in various regions, it is doubtful whether periodicity of radial growth can be accepted as a basic physiological characteristic of citrus. The extent of radial growth may depend on tree age, air temperature, and the supply of soil moisture and nutrients. Radial growth may proceed during the winter in young trees with ample soil moisture and nutrients in regions where temperatures are generally above 55°F.

EXTENSION GROWTH OF ROOTS

Crider (1927) reported that three cycles of shoot elongation alternated with three cycles of root elongation in young citrus trees in Arizona. He found that an extended dormant period occurred in the winter during which neither shoots nor roots grow, and shoot growth preceded root growth in the spring. Waynick and Walker (1930) reported similar results for several citrus species in the coastal area of California, and Reed and MacDougal (1938) confirmed these results to some extent for California. Schneider (1952), also in California, failed to find an alternation of cycles of root and shoot growth. Abundant root growth was observed at all times except from December to April and for a brief period in August.

In Palestine and South Africa, where soil temperatures rarely fall below 60°F during the winter, three cycles of root growth occur and the most active cycle is in the winter (Cossman, 1945; Marloth, 1948). A trend towards alternation in periodicity of root and shoot growth is indicated for small trees in the nursery in these citrus areas, but soil moisture and soil temperatures are important factors influencing the time and duration of the growth cycles.

Only scant data are available on root growth in citrus in the Rio Grande Valley. Extension growth of roots was determined on three-year-old grapefruit trees during the fall and winter of 1956-57 by observing whether new white tips were present. A trench about 1½ foot deep was dug, and a window glass was placed over one side of it in such a way that feeder roots were near the glass. The trench was covered with a board over which 12 inches of loose soil was placed. Abundant root

growth was observed during October, November and moderate root growth during December and January.

In summary, root growth in citrus occurs in cycles, but it is doubtful that there is a regular alternation of root and shoot-growth cycles except possibly on small trees. Roots are dormant in the winter in California, where soil temperatures are generally below 55°F, but root growth on young trees occurs in the winter in Palestine, in South Africa and in the Rio Grande Valley, where soil temperatures are generally above 55°F.

CONTROL OF PERIODICITY

Soil moisture is an important factor influencing both the time and the duration of root- and shoot-growth cycles. Dormancy induced by drought may occur at a wide range of soil temperatures and at any time of the year, and, when superimposed on normal dormancy, may confound the effects of normal dormancy. Drought not only interrupts extension growth of shoots but also inhibits extension growth of roots and cambial activity in all parts of the tree (Cooper et al, 1955). When water is applied to the soil following an extended dry period, a new flush of shoot growth will follow within approximately two weeks. Casual observations on the appearance of the new shoot growth following drought indicate that, though the severity of drought may influence the vigor of the growth, there is no basic difference between it and the new growth occurring on trees with ample soil moisture. The terminal bud of the new shoot aborts and normal dormancy of the shoot follows. There is, however, a need for more investigation on this subject.

Soil and air temperatures below 55°F are important factors influencing the periodicity of shoot and root growth. Very little information is available on the growth of citrus under controlled temperatures, but the studies of Girton (1927) and Halma (1936) indicate that the minimum temperatures are 55° for growth of orange trees, 51° for grapefruit and about 45° for lemon. In California the mean daily air temperature is generally below 55° during the winter and under such conditions extension growth of shoots and roots and cambial activity of the shoots, branches and trunk of orange trees cease (Reed and MacDougal, 1938; Cameron and Schroeder, 1945; Chandler, 1950; Schneider, 1952). Such trees in the presence of ample soil moisture may be as dormant as trees with drought-induced dormancy.

In the lower Rio Grande Valley of Texas, where the mean daily air temperature during December and January is generally about 63°F and the mean daily temperature of the soil at nine inches is approximately the same, there is generally no shoot elongation in orange and grapefruit trees between November 15 and January 15, but the cambium in the shoots, branches and trunk of the tree is active and there may be root growth. Thus, the winter dormant period in Texas is principally an interruption of shoot growth while that in California may involve a cessation of shoot, root and cambial growth. The period of dormancy is also longer in California than in Texas. The lower soil and air temperatures in California, therefore, appear to influence principally root and cambial growth. The interruption of shoot growth is thus attributed to causes other than low temperature.

The daylength is known to influence extension growth of many tree species. Downs and Borthwick (1956) report that, in general, short days induce dormancy and long days prolong extension growth of shoots. The daylength in California is shorter than that in the lower Rio Grande Valley of Texas. Four 3-year-old grapefruit trees with dormant buds, growing in the orchard in the Rio Grande Valley, were exposed to an 8-hour day for six weeks beginning on December 1, 1954. This was accomplished by placing a large light-tight box over the trees each day at 4 p.m. and removing it at 8 p.m. The treatment induced a new flush of growth. However, the effect of the short day was confounded by a 10-degree warmer night temperature than occurred around trees outside of the box.

Haas (1951) reported increasing growth of citrus trees during the winter in California by exposing them to a 24-hour day. These limited studies are inadequate to appraise properly the effect of photoperiod on periodicity of growth in citrus, but it does appear that the photoperiod is not the major factor in controlling the periodicity of growth.

The results summarized in this review corroborate a suggestion by Marloth (1948) that under favorable growing conditions some unidentified internal factor controls periodicity of shoot growth in citrus. Doorenbos (1953) also made a similar suggestion to explain intermittent growth common in most evergreen trees in the tropics. For such cases Doorenbos used the general term "summer dormancy."

An explanation of the internal factor may be that after rapid elongation of the new shoot some physiological condition, perhaps an excess or lack of some kind of plant regulator, develops within the shoot and causes the terminal bud to abort. The cause does not appear to be an excess or lack of any of the common mineral nutrients as the phenomenen occurs under a wide variety of nutritional conditions. It is known (Cooper, 1939) that the immature leaves on new shoots of citrus produce large amounts of auxin, a plant regulator, but there is no evidence that auxin causes abortion of the terminal bud. Recent work by Marth et al (1956) shows that gibberellie acid in a 1 percent lanolin paste mixture greatly stimulates growth of young growing shoots of citrus seedlings under greenhouse conditions. The same treatment applied to young growing shoots of grapefruit in the Rio Grande Valley increased shoot elongation, delayed abortion of the terminal bud and induced growth in lateral buds on the new shoot (Cooper[3]). Also, when a spray containing 100 ppm. gibberellic acid was applied on December 15 to young grapefruit trees with dormant buds, a general flush of new growth began in all lateral buds on the terminal shoot on December 30 while buds on untreated trees remained dormant until January 25 (Cooper[3]). It may be that elongation of shoots is controlled by a naturally occurring plant regulator similar to gibberellic acid, and the abortion of the terminal bud and inhibition of lateral buds are caused by a lack of this regulator or by its inhibitor.

[3] Cooper, W. C., 1957. Unpublished data.

Further studies on the chemical induction and inhibition of dormancy in citrus are needed. Likewise, an investigation of dormancy under controlled temperature and daylength conditions would be of great aid to the solution of the cold-hardiness problem in citrus.

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Comparison of Several Iron-Chelating Agents in Correcting Iron Chlorosis in Dancy Tangerines In the Rio Grande Valley[1]

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INTRODUCTION

Various iron chelates to correct iron chlorosis of citrus growing in calcareous soils in the Rio Grande Valley have been under test for the past 4 years. Variable results ranging from no response to a complete regreening of chlorotic grapefruit leaves were obtained with Sequestrene NaFe[2] (ethylenediamine tetraacetic acid) and with Versenol Iron Chelate NaFe[2] (hydroxy-ethylene diamine triacetic acid) used at rate of 1 to 5 grams of metallic iron per 2-year-old tree (Cooper and Peynado, 1954 and 1955). In 1955 iron chelated with Sequestrene 330 Fe[2] (diethylenetriamine pentaacetic acid) and with Chel 138 HFe[2] (an aromatic amine) were tested. Sequestrene 330 Fe applied at rates of 1 to 5 grams of iron per 2-year-old tree reduced iron chlorosis but did not cause complete regreening of all trees, while Chel 138 HFe applied at the rate of 1 gram of iron per 2-year-old tree caused complete regreening of all trees (Cooper and Peynado, 1956). This present paper compares results of Chel 138 HFe[2] and Versinol iron chelate with results of 2 new iron chelates: namely RA 157 Fe (chemical name unknown)[2] and RA 159 Fe (chemical name unknown).[2] RA 157 Fe has been found to be highly effective in correcting iron chlorosis of citrus on California and Arizona in experiments conducted concurrently with these in Texas (Armstrong, 1957; Hilgeman, 1957).

METHODS

The trees used in these tests were 3-year-old Dancy tangerine on Cleopatra mandarin rootstock in a grove of Floyd Everhard at Mission. The soil in the test area was Rio Grande fine sandy loam and contained numerous small snail shells. The calcium carbonate content of the surface foot of soil ranged from 2 to 3 per cent and pH was 7.9.

The iron chelates were applied to the soil over a 4-square-foot area around the trunks of the tree and were chopped into the soil with a hoe. On May 22, 1956, each of the 4 materials was applied at the rates

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U. S. Department of Agriculture, certain phases of which were carried out under the Agricultural Marketing Act (RMA Title II).

[2] Sequestrene NaFe and Sequestrene 330 Fe are commercial products manufactured by Geigy Agricultural Chemicals while Versenol Iron Chelate NaFe is manufactured by Dow Chemical Co. Chel 138 HFe, RA 157 Fe and RA 159 Fe are experimental iron chelates supplied by Geigy Agricultural Chemicals.

of 1 and 5 grams of metallic iron per tree. One tree was treated at each rate of application for each material in each of 3 rows. The trees were 25 feet apart in rows 25 feet apart. In a second experiment started on July 22, Chel 138 HFe and RA 157 Fe were applied at the rates of 1, 2.5 and 5 grams of metallic iron to single trees in each of 5 rows. The trees were rated for severity of iron chlorosis at the time of application of the iron chelates and 2 months later.

RESULTS AND DISCUSSION

The 4 iron chelates differed in their effectiveness in correcting iron chlorosis on Dancy tangerines (table 1). During the period of these observations there was no indication of regreening of the chlorotic foliage of the untreated trees or of the trees treated with Versinol Iron Chelate NaFe at the rate of 5 grams of metallic iron per tree. Trees treated with RA 159 Fe showed slight regreening, while those treated with Chel 138 HFe showed nearly complete regreening and those with RA 157 Fe showed complete regreening. Chel 138 HFe and RA 157 Fe were just as effective at the 1-gram rate of application as at 5, while 5 grams of RA 159 Fe was considerably more effective than 1 gram.

Table 1. Severity of iron chlorosis in mature leaves of Dancy tangerines on Cleopatra mandarin rootstocks in relation to soil treatment with chelated iron materials, Mission, Texas, 1956.

Date of treatment and material	*Metallic iron per tree (grams)*	*Severity[a] of iron chlorosis*		
		Before treatment	*2 months after treatment*	*Decrease in 2-month period*
May 22[b]:				
None	0	1.7	1.7	0
Versenol Iron Chelate NaFe	5	2.3	2.3	0
Chel 138 HFe	1	2.3	0.3	2.0
	5	2.3	0.3	2.0
RA 157 Fe	1	2.7	0	2.7
	5	3.0	0	3.0
RA 159 Fe	1	2.7	2.3	0.5
	5	3.0	1.3	1.7
July 22[c]:				
None	0	3.0	3.0	0
Chel 138 HFe	1	2.4	0	2.4
	2.5	2.2	0	2.2
	5	2.0	0	2.0
RA 157 Fe	1	1.8	1.6	0.2
	2.5	3.0	0.8	2.2
	5	3.0	0.5	2.5

[a] The key to rating for severity of iron chlorosis:
0, no iron chlorosis; 1, less than half of leaves chlorotic; 2, nearly all the leaves chlorotic; 3, all leaves chlorotic and some defoliation.

[b] 3 trees for each treatment

[c] 5 trees for each treatment

Because of the superior effectiveness of Chel 138 HFe and RA 157 Fe in the experiment just described, these two materials were used again in an experiment started on July 22, 1956. The results, given in table 2, shows that both materials were again highly effective in regreening chlorotic foliage. However, whereas RA 157 Fe was slightly more effective than Chel 138 HFe in the first experiment, just the reverse occurred in the second experiment. The two materials are available only in limited quantities and cannot be purchased for commercial use at this time.

SUMMARY

Three-year-old Dancy tangerine trees on Cleopatra mandarin rootstock, growing in a commercial orchard on calcareous soil and showing severe iron chlorosis, were given soil applications of Versenol Iron Chelate NaFe, Chel 138 HFe, RA 157 Fe and RA 159 Fe at the rates of 1 to 5 grams of metallic iron per tree. The decrease in iron chlorosis during a 2-month period following treatment was used as an index of the effectiveness of the materials.

At a 5-gram rate of application Versenol Iron Chelate NaFe was ineffective, RA 159 Fe slightly effective, and Chel 138 HFe and RA 157 Fe were highly effective. The last two were also highly effective at a 1-gram rate of application.

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Response of Orange Trees Growing in the Salt River Valley of Arizona to Chelated Iron Compounds

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INTRODUCTION

Under Arizona conditions iron or lime induced chlorosis caused by a deficiency of iron usually develops gradually on large trees after they are 15 to 20 years old. First evidence of the deficiency is the appearance of a few chlorotic leaves, principally on the lower part and on the north side of the tree. As the deficiency becomes more acute chlorotic leaves occur irregularly over most of the tree. Death of woody tissues then follows beginning with the small twigs and gradually affecting the larger branches. Frequently about ten years are required from the onset of the chlorosis before the extremely severe die-back condition develops. While iron chlorosis may be general throughout a grove, in many instances only a few trees are affected and these may be irregularly located and adjacent to normal trees.

The first work on chlorosis done in Arizona by Burgess and Pohlman (2) attempted to correct the condition by fertilization with nitrogen, phosphorus, potassium, magnesium, iron sulfate or manure. None of these materials, nor the application of soil amendments such as sulfur, gypsum or aluminum sulfate were effective. They found the problem associated with high soil moisture and were able to cause a marked improvement in tree condition by limiting irrigation.

Recovery of trees by placing ferric citrate and ferrous sulfate in holes bored in the trunks was obtained by Kinnison, Albert and Finch (1). Applications of ferrous sulfate to the soil produced irregular results, and leaf sprays with iron caused a transient green spotting. McGeorge (5) associated the problem with soils containing more than three per cent calcium carbonate and having a pH of the soil paste above 8.3. He recommended the use of acid soil correctives in addition to the suggestions of previous workers.

Practical field experience has shown in most instances that modification of irrigation has produced beneficial results, but the responses tended to be slow. Where the water holding capacity of the soil varies markedly within a grove, it has been difficult to change the schedules to produce the desired effect. Where small areas or individual trees are affected modification of irrigation has not been practical. Responses from tree injections have been variable and iron sprays have produced only moderate spot regreening of leaves with no basic improvement in the condition of the tree. Acid soil correctives have not produced definite responses under field conditions.

The recent discovery by Leonard & Stewart (4) that the iron chelate

NaFe EDTA provided a source of iron which remained stable in the soil solution and was readily absorbed by the roots of chlorotic trees growing in acid soils, provided a new method of attack on the problem. Accordingly field tests were initiated in June, 1953, with iron chelate materials.

MATERIALS AND METHODS

Tests with iron chelate materials were made in four groves in the Salt River Valley. Grove A: University of Arizona Citrus Experiment Station; 21-year-old Valencia orange trees on sour orange root; calcareous gravelly sandy loam soil with caliche at 30 inches. Grove V: Val Vista Grove: 15-year-old Valencia and Washington Navel on sweet orange root; fine sandy loam soil with no caliche layer, generally underlain with river rocks. Grove C: Schornick Grove: 28-year-old Valencia orange trees on sour orange root; loam soil with caliche at 42 inches. Grove D: Thayer Grove; 28-year-old Washington Navel trees on sour orange root; loam soil with highly variable caliche.

The following materials were tested:

1.	Sequestrene NaFe	NaFe EDTA	12.0% Fe
2.	Sequestrene 330 Fe (formerly Chel. 330 Fe)	NaFe DTPA	10.5% Fe
3.	Chel. 138 HFe	HFe EDDHA	10.3% Fe
4.	RA 157 Fe		7.6% Fe
5.	RA 159 Fe		2.7% Fe
6.	Versenol Iron Chelate on Vermiculite	NaFe HEEDTA	5.0% Fe
7.	Iron Sulfate (Commercial grade)		20.0% Fe

In 1953 the Sequestrene NaFe was dissolved and applied in 30 holes 18 inches deep around the drip of the trees. During 1954 and through June, 1955, all materials were applied in a shallow trench about six inches wide and five inches deep which extended slightly into the zone of the surface feeder roots just outside the drip of the tree. Beginning in July, 1955, and thereafter, all materials have been applied uniformly to the soil in a basin surrounding the tree which extended up to the tree trunk. The area within the basin amounted to approximately 400 square feet. The materials were uniformly broadcast within the basin and lightly hoed before irrigating into the soil with approximately five inches of water.

RESULTS

No responses were obtained from one pound of Sequestrene NaFe applied to Valencia orange trees in Grove D in June, 1953. No further tests have been made.

* Sequestrene NaFe and Sequestrene 330 Fe are commercial products; and Chel. 138 HFe, RA 157 Fe and RA 159 Fe are experimental iron chelates. Both were supplied by Geigy Agricultural Chemicals. Versenol Iron Chelate NaFe is manufactured by Dow Chemical Co.

Tests with Sequestrene 330 Fe and Versenol Iron Chelate

Preliminary tests were made in Grove A to four trees which were growing under a high level irrigation program in which the soil moisture tensions were constantly below 500 cm. of water at the 18 inch depth. This program had induced iron deficiency symptoms in 25 to 40 per cent of the leaves on the trees. Two pounds of Sequesetrene 330 Fe and one gallon of sulfuric acid were applied on June 14, 1954. Marked response had occurred by July and in September less than five per cent of the leaves had chlorosis patterns. The trees continued to gradually improve for approximately one year. Thereafter, chlorosis began to again increase slightly. In September, 1956, three of the four trees were still in very good condition with from one to seven per cent of the leaves affected with chlorosis (Table 1). The high level of irrigation was maintained during the test.

After the response in Grove A became evident, a test in Grove B was started to test the effect of the sulfuric acid. In July, 1954, four trees were treated with two and one half pounds of Sequestrene 330 Fe, and one gallon of sulfuric acid. Regreening of the trees treated with Sequestrene 330 Fe alone and with acid was similar. Trees treated with only sulfuric acid were similar to the control and showed no regreening. It was evident that the acid had no effect on the action of the Sequestrene 330 Fe. Regreening in this test occurred more slowly than in Grove A. Only slight improvement was evident about 2 months after application. Marked improvement occurred in the spring and early summer of 1955. Slight increases in chlorosis developed in two of the eight trees during 1956 (Table 1).

Further tests with Sequestrene 330 Fe were conducted in 1955 and 1956 to obtain information on rates of application. One pound of the material was applied to six trees under the high soil moisture treatment in Grove A. Some regreening occurred but it was not a satisfactory response. These trees were again treated with two pounds in May, 1956,

Table 1. Effect of Sequestrene 330 Fe applied in 1954 on regreening of Valencia orange trees.

Grove	No. Trees	Material	Amount Applied	Date	Avg. pct. of chlorotic leaves June '54	July '54	Sept. '54	Aug. '55	Sept. '56
A	4	Seq. 330 Fe plus H_2SO_4	2½# 1 gal.	6/14	33	7	3	4	6
	4	Control		–	32	28	32	27	20
B	4	Seq. 330 Fe plus H_2SO_4	2½# 1 gal.	7/21		35	28	4	6
	4	Seq. 330 Fe	2½#	7/21		30	23	5	6
	4	H_2SO_4	1 gal.	7/21		40	28	38	26
	4	Control				32	32	36	30

which resulted in excellent regreening during the following three months. Versenol Iron Chelate was also applied to a similar group of trees.

Almost no response occurred from two pounds of the material in 1955 but moderate irregular regreening developed after a five pound application in 1956 (Table 2).

Trees in grove B treated on May 27, 1955, with one half, one and two pounds of Sequestrene 330 Fe showed only slight to moderate improvement in the two month period after treatment. Regreening continued throughout the year and the degree of chlorosis was markedly reduced. However, the response was not as uniform and extensive in this test as it was in the previous year. While the two pound rate produced generally the best responses, a very good response was obtained on one tree which received only one half pound (Table 2).

Another trial was made on June 3, 1955, in grove C with trees which had from 40-90 per cent chlorosis and up to 75 per cent die back. Treatments were one and two lbs. of Sequestrene 330 Fe, two pounds of Versenol Iron Chelate and 20 lbs. of iron sulfate. The initial responses to Sequestrene 330 Fe were slightly greater from two pounds of the material than from one pound. One year after treatment six of the eight trees treated had less than five per cent chlorosis. One tree which received one pound had a very poor response. Versenol Iron Chelate produced no repsonse, but three of the four trees treated with iron sulfate showed marked improvement. Because iron chlorosis had been general in this grove, irrigations were delayed until the trees showed marked moisture stresses. This program appears to be responsible for the improvement noted in the control trees.

Table 2. Effect of Sequestrene 330 Fe and Versenol Iron Chelate on regreening of orange trees.

Grove	No. Trees	Material	Amount Applied (lbs.)	Date Applied	Avg. pct. of chlorotic leaves May '55	Aug. '55	Oct. '55	Apr. '56	Sept. '56
A	6	Seq. 330 Fe	1	6/ 1/55	37	22	18		
			2	5/ 9/56				20	3
	6	Vers. Fe Chel.	2	6/ 1/55	38	36	33		
			5	5/ 9/56				35	6
	5	Control	5	–					
B	3	Seq. 330 Fe	2	5/27/55	63		43		11
	3	Seq. 330 Fe	1	5/27/55	66		46		5
	3	Seq. 330 Fe	½	5/27/55	53		46		16
	3	Vers. Fe Chel.	2	5/27/55	48		47		45
	3	Control	–		43		43		26
C	4	Seq. 330 Fe.	2	6/ 3/55	57	40		18	5
	4	Seq. 330 Fe	1	6/ 3/55	58	46		22	8
	4	Vers. Fe Chel.	2	6/ 3/55	59	58		57	53
	4	Iron Sul.	20	6/ 3/55	66	61		59	36
	4	Control	–	6/ 3/55	58	58		59	36

Tests with Experimental Iron Chelates

In a preliminary test applied on June 15, 1955, four trees in Grove A were treated with Chel 138 HFe. When extremely rapid regreening developed, a more detailed test was applied in Grove D on July 20. The material was applied broadcast at rates of 24, 48 and 96 grams of iron per tree. Three trees were treated at each rate. Regreening started within a few days after treatment and within six weeks 95 per cent recovery had occurred. Greening of leaves followed an irregular pattern with large irregular areas in the leaves becoming green. This "spottle" gradually disappeared as the entire leaf became green. Leaves which were completely devoid of green color had 50 to 100 per cent regreening. Profuse new growth started and all new leaves had a deep green color. One tree which received one half pound failed to completely recover. Fifteen months after application the older leaves were still a deep dark green, but the late summer and fall growth was showing evidence of the development of chlorosis (Table 3).

This experiment was followed by another test applied in the same grove on May 19, 1956, in which the materials were applied at the rate of 12, 24 and 48 grams of iron per tree from Chel. 138 HFe and from Geigy Experimental compounds RA 157 Fe and RA 159 Fe. Sequestrene 330 Fe was applied at rates of 96 and 192 grams of iron per tree and

Table 3. Effect of Chelated iron compounds on regreening of Washington navel orange trees in grove D.

Material	*Am't iron appl'd (grams)*	*Average Percent Chlorosis* 1955 *July 20*	*Aug. 9*	*Oct. 11*	*1956 Apr. 7*	*Sept. 17*	*Response—Remarks*
Chel. 138 HFe (a)	24	73	60	32	28	10	Variable; fair to Excell.
	48	80	25	4	2	3	Excellent
	96	80	23	3	2	2	Excellent
Control	–	75	75	75	82	45	Variable Impr. 1956
		1956 *May 2*	*June 26*	*Sept. 11*			
Chel. 138 HFe (b)	12	47	7	1			Excellent
	24	48	7	2			Excellent
	48	40	3	0			Excellent
RA 157 Fe (b)	12	35	33	18			Unsatisfactory
	24	52	27	7			Variable, fair-good
	48	47	6	4			Very good
RA 159 Fe (b)	12	32	32	30			Poor
	24	50	47	33			Variable, fair
	48	50	47	38			Variable, fair-good
Seq. 330 Fe (b)	96	48	25	8			Very good
	191	40	25	4			Very good
Vers. Fe Chel (b)	113	20	19	10			Variable; fair
Control		48	53	47			None

(a) Materials applied to 3 trees at each rate on July 20, '55
(b) Materials applied to 3 trees at each rate on May 19, '56

Versenol Iron Chelate at 112 grams of iron per tree. All rates of Chelate 138 HFe produced excellent responses in that all trees had less than five per cent chlorosis by September. Sequestrene 330 Fe applied at the high rates of two and four pounds per tree produced more rapid responses than was previously observed. Versenol Iron Chelate also produced a definite response with about a 50 per cent improvement in the number of chlorotic leaves. RA 157 Fe produced slower responses than Chel. 138 HFe and produced maximum effects at the 48 gram rate of application. The RA 159 Fe compound was largely ineffective (Table 3).

DISCUSSION

The irregular rates of regreening obtained from Sequestrene 330 Fe during these tests suggest that the uptake of the materials may be influenced by the physiological condition of the trees. However, it appears also possible that it reflects a failure to apply the chelated iron to the active roots. Under the program in use in 1954 and until July 1955 the materials were applied in shallow trenches around the drip of the trees. Under this method the material may not have been placed at the most active portions of the root systems. When the materials were applied to the entire soil area surrounding the tree, as was done in 1956, more uniform results were obtained. The increased rate of re-greening from Sequestrene 330 Fe as successively larger amounts of the material was applied suggests that part of this material may become insoluble after application. The continued response over a relatively long period may indicate that it again becomes available. Further investigations of the characteristics of this material in loam soil is required.

Of the experimental materials, Chel. 138 HFe has been outstanding in producing rapid regreening of old leaves and in stimulating new growth. Since responses have been obtained from very small amounts of the material, it appears that it may be of commercial value even though the manufacturers indicate the cost per pound may be relatively high.

The results of Cooper (3) indicate that RA 157 Fe and RA 159 Fe were more effective in correcting chlorosis than these materials were in the tests reported here. This may possibly be caused by the higher concentration of the materials in the root zone in Cooper's tests. He applied from .25 to 1.25 grams of iron per square foot, whereas the same materials were applied at rates of .03 to .12 grams of iron per square foot in the tests reported in Table 3.

It has been demonstrated that Sequestrene 330 HFe, Chel. 138 HFe and RA 157 Fe are readily absorbed and produce rapid regreening of leaves. The length of time the tree will remain green after the chelate materials have been either used up or leached below the root system has not been demonstrated. It appears that such effects will depend largely upon the basic factors which originally caused the tree to become chlorotic. If reduced root activity due to improper soil aeration is involved, a change in the irrigation program to alleviate this condition is required. If the condition is largely caused by the high calcium carbonate content in the soil, a basic soil problem is involved which possibly can only be alleviated by regular applications of compounds containing available iron.

SUMMARY

Tests were made with chelated iron compounds in four groves between 1953 and 1956. Rapid and almost complete regreening was obtained from Chel. 138 HFe applied at rates of 12 or 24 grams of iron per tree. Less rapid but satisfactory regreening was obtained from RA 157 Fe and from Sequestrene 330 Fe applied, respectively, at rates of 48 and 96 grams of iron per tree. Sequestrene 330 Fe was approximately equally effective in four soil types with trees growing on both sour and sweet orange rootstocks. The best results were obtained when the materials were applied during May by broadcasting uniformly in a basin extending over the entire root area and irrigating into the soil.

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Comparison of Several Materials in Correcting Iron Chlorosis of Trifoliate Orange and Rangpur Lime Seedlings in California

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INTRODUCTION

Control of lime-induced iron chlorosis is influenced by many factors including soil, irrigation practice, variety of plant and kind and amount of soil amendment used. Wallace, Mueller, Lunt, Ashcroft and Shannon (1955) in laboratory studies showed that clay soils fixed certain chelating agents, but not others. Butler and Bray (1956) showed that a greater quantity of chelate was fixed in a silt loam than in a fine sand. Wallace et al. (1955) further showed that two compounds were capable of maintaining a high level of available iron in calcareous soils, but only Chel. 138 HFe, the ferric chelate of an amino polycarboxilic acid, was able to overcome both fixation by the clay soils and precipitation of iron by calcareous soils. Cooper and Peynado (1956) obtained similar results.

Cooper and Peynado (1954, 1955) in Texas and Armstrong and Furr (1956) in the Coachella Valley of California found that chlorosis may be controlled by heavy applications of Sequestrene NaFe (the ferric chelate of ethylenediaminetetraacetic acid) and Versenol Iron Chelate NaFe (the ferric chelate of hydroxyethylethylenediaminetriacetic acid). Wallace, Mueller, Lunt, Ashcroft and Shannon (1955) and Cooper and Peynado (1955) showed that Sequestrene NaFe and Versenol Iron Chelate NaFe, which are less effective than Chel 138 HFe (the ferric chelate of an aromatic amine) in alkaline calcareous soils, may be toxic to plants when applied at the high rates necessary to control chlorosis.

Until the advent of synthetic chelates, ferrous sulfate was often used as an iron-containing soil amendment. Locke (1953) found that ferrous sulfate was effective in controlling chlorosis in grapes, while Cooper and Peynado (1954), Stewart and Leonard (1952), and Hoveland (1954) obtained no benefit from it in citrus and ornamentals. Results obtained in 1954 and 1955 by Armstrong and Furr (1956) indicate that at high rates ferrous sulfate was effective in controlling chlorosis in trifoliate orange *(Poncirus trifoliata)*.

This paper reports: (a) further results obtained in the 1954 trial in the Coachella Valley, California, by Armstrong and Furr, (b) the results of a commercial trial of ferrous sulfate, (c) a trial of several iron chelates in 1956.

EXPERIMENTS

(a) *1954 Trial*

In the spring of 1954 a replicated trial of several application rates of five materials for the control of iron chlorosis was begun. The results to October 19, 1955, were reported by Armstrong and Furr (1956). Of 19 treatments applied, 9 reduced chlorosis for 6 months, but only 4 treatments were successful in significantly controlling chlorosis for 17 months. When the trees were evaluated on October 19, 1955, the most effective treatment was 100 grams of ferrous sulfate per square foot, the second most effective treatment was 4 grams of iron per square foot as Sequestrene NaFe, the third was 50 grams of ferrous sulfate per square foot and the fourth was 2 grams of iron per square foot as Versenol Iron Chelate NaFe.

By October 2, 1956, approximately 29 months after treatment, only trees on soil treated with the two highest rates of ferrous sulfate were less chlorotic than the controls. Butler and Bray (1956) and Antognini (1954) showed that some chelates have an effective life in the soil ranging from only a few months to a year because they are decomposed, complexed, or perhaps leached out of the root zone. The results of the present trial suggest that ferrous sulfate may have an effective life extending into several years; Locke (1953) came to the same conclusion.

(b) *Commercial Trial of Ferrous Sulfate*

On February 22, 1956, Albert Newcomb, a commercial nurseryman in the Coachella Valley, planted a seedbed of trifoliate orange. The soil mixture used to cover the seeds contained slightly less than 1 per cent by volume of ferrous sulfate. Five additional surface applications of 25 pounds of ferrous sulfate per 1000 square feet were made at intervals between June and September, 1956. Figure 1 indicates the appearance of this seedbed on October 26, 1956. The plants were of excellent vigor, averaging 24 to 28 inches tall, and showed no symptoms of iron chlorosis. Plants in an adjacent untreated bed were severely chlorotic and approximately half as tall as those in the treated bed. Water applied by the sprinkler-irrigation system used on this bed failed to wash all of the ferrous sulfate off of the plants and some burning of leaves and stems occurred after the summer applications. Since ferrous sulfate is nontoxic when incorporated in the soil and is effective over long periods, it is probable that leaf and stem burn can be avoided by using a higher percentage in the covering mixture and no supplemental applications.

(c) *1956 Trial*

On June 20, 1956, a 9x9 latin square experiment was begun to compare the effectiveness in the Coachella Valley of several new iron chelates with the older Sequestrene NaFe. The individual plots were 2 feet by 2 feet and were separated by buffer strips 2 feet wide. One trifoliate orange seedling of about ¼-inch caliper and one Rangpur lime seedling of about ⅛-inch caliper were planted about 2 inches apart near the center of each plot.

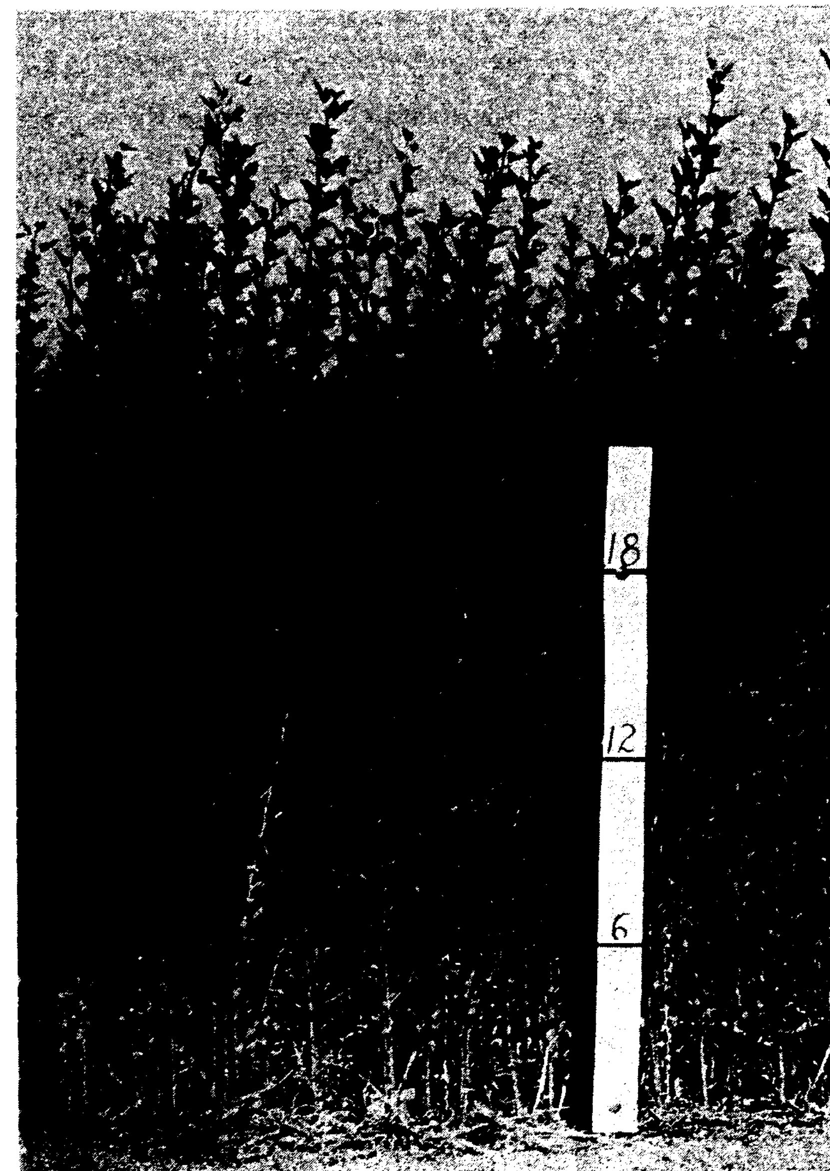

Figure 1. 35-week-old *P. trifoliata* seedlings in a seedbed treated with ferrous sulfate. The scale is in inches.

The soil used in the experiment was moderately heavy Indio loam with a calcium carbonate content of over 10 per cent. When moisture in this soil is kept high, *P. trifoliata* plants soon develop very serious iron chlorosis, which may in time kill them. Somewhat less serious chlorosis usually develops in Rangpur lime maintained under similar conditions on this soil. The *P. trifoliata* seedlings used in this experiment were 1 year old, had been grown in an open seedbed in soil and were chlorotic when planted in the experimental plots. By early July they were well established and had produced a new flush of very chlorotic growth. On July 9 the experimental materials were spread evenly over the surface of the plots and hoed in to a depth of about 1 inch.

The five materials[1] used were Sequestrene NaFe; Sequestrene 330 Fe (the ferric chelate of diethylenetriaminepentaacetic acid); Chel 138 HFe; Ra 157 Fe (chemical name unknown) and RA 159 Fe (chemical name unknown). Rates of application are listed in Table 1. Throughout the experiment the soil was maintained at a high moisture level. At the periodic evaluations each seedling was given a numerical grade based on color, vigor and symptoms of toxicity. The key to this rating is given as a footnote to Table 1.

The Rangpur lime seedlings reacted to treatment with such variability that there was no significant difference among the treatments.

An analysis of the evaluation made on July 31, 1956, showed that 22 days after application, *P. trifoliata* plants in 7 treatments were greener than the control plants (Table 1). The 7 effective treatments were Sequestrene 330 Fe at 0.5, 1.0, 2.0 grams Fe per square foot. Sequestrene NaFe, Chel 138 HFe, Ra 157 Fe and RA 159 Fe. Sequestrene 330 Fe at 1.0 gram Fe per square foot, Sequestrene NaFe, and Chel 138 HFe caused toxicity symptoms in the plants. One hundred twenty-two days after application, plants in 6 treatments, Sequestrene 330 Fe at 0.5, 1.0, 2.0 and 4.0 grams of Fe per square foot, Chel 138 HFe and RA 157 Fe, were less chlorotic than those in the control plots. Sequestrene 330 Fe at 1.0, 2.0, 4.0 grams of Fe per square foot and Chel 138 HFe caused toxicity symptoms. Two-thirds of the *P. trifoliata* trees treated with Sequestrene NaFe showed severe toxicity symptoms, sometimes followed by death of the plants; an equal rate failed to cause toxicity symptoms in the 1954 trial. When Sequestrene 330 Fe was applied at rates of more than 0.5 gram of iron per square foot it produced increasingly severe toxicity symptoms. RA 159 Fe cured chlorosis early in the trial, but the effect was short-lived, since by November the plants treated with it were as chlorotic as the controls; it produced toxicity symptoms in two of the nine plants.

CONCLUSIONS

While applications of ferrous sulfate to the soil have given variable and contradictory results, ferrous sulfate seems to have a long life, ap-

[1] Manufactured and supplied by Geigy Agricultural Chemicals

Table 1. Results of treatments applied July 9, 1956, to seedlings of *Poncirus trifoliata* for the control of iron chlorosis, Coachella Valley, California.

Treatment		Observations on chlorosis and toxicity				Number of plants showing toxicity symptoms[1], 9 plants per treatment	
		After 22 days		After 122 days			
Material[2]	*Grams Fe per sq. ft.*	*Rating*[3]	*Description*	*Rating*[3]	*Description*	*After 22 days*	*After 122 days*
Control		3.8	Severe chlorosis	4.5	Severe chlorosis	0	0
Sequestrene 330 Fe	0.5	1.9	No chlorosis	1.9	No chlorosis	0	0
	1.0	2.5	Slight toxicity	2.6	Moderate toxicity	1	2
	2.0	1.7	No chlorosis	2.1	Slight toxicity	0	1
	4.0	3.2	Moderate toxicity	2.6	Moderate toxicity	3	3
Sequestrene NaFe	4.0	2.7	Moderate toxicity	4.4	Severe toxicity	3	6
Chel. 138 HFe	0.5	2.3	Slight toxicity	2.5	Moderate toxicity	1	2
RA 157 Fe	2.0	1.9	No chlorosis	1.5	No chlorosis	0	0
RA 159 Fe	2.0	2.2	Moderate chlorosis	3.1	Moderate toxicity	0	2
LSD, 1%		1.0		1.8			

[1] Toxicity symptoms range from severe leaf burn to death of plant.

[2] Abbreviations explained in text.

[3] The rating indicates a combination of severity of chlorosis, vigor of growth and toxicity effects. A rating of 1 indicates excellent growth and no chlorosis; 2, good growth and some chlorosis; 3, fair growth and many chlorotic leaves; 4, severely stunted growth, very chlorotic leaves and some twig dieback; 5, severe toxicity symptoms with or without temporary control of chlorosis; 6, death of plant due to chlorosis or to toxicity of chemical.

parently is non-toxic even when used at massive rates, is of moderate cost, and occasionally produces striking results. In the Coachella Valley its use at moderate rates as a soil application to *P. trifoliata* seedbeds was of benefit.

Sequestrene NaFe in the 1954 trial produced no toxicity symptoms in *P. trifoliata,* but in the 1956 trial it was the most toxic of all materials tried. Its use at the high rates necessary to control iron chlorosis in plants grown in calcareous soil was of questionable value in these experiments.

Sequestrene 330 Fe, toxic at high rates, but very effective at 0.5 gram of iron per square foot, may prove to be as economical and effective as ferrous sulfate in the treatment of chlorosis in nursery stock.

Since Chel 138 HFe was only moderately effective in curing chlorosis and produced some toxic symptoms, it may be of little practical interest.

RA 157 Fe was the most effective material used in the 1956 trial and produced no toxic symptoms. Further tests of this promising compound should be made. RA 159 Fe, which gives a short-lived correction of chlorosis followed by toxicity symptoms, showed little promise.

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Effect of Bud-Transmitted Diseases on Size of Young Valencia Orange Trees on Various Rootstocks[1]

E. O. OLSON, W. C. COOPER and A. V. SHULL

INTRODUCTION

When scions carry the bud-transmitted viruses causing xyloporosis (cachexia), exocortis (Rangpur lime disease) and psorosis of citrus, the evaluation of rootstocks from a horticultural viewpoint is extremely difficult. Cooper, Olson, Maxwell and Otey (1957) found that exocortis and xyloporosis viruses limited the potential usefulness of many rootstocks for Shary Red or Webb Red Blush grapefruit tops. The present paper deals with the same problem on Valencia orange trees on various rootstocks, with one important difference: some psorosis-free trees used as sources of budwood in this experiment were free of exocortis and xyloporosis viruses, and some were not. In the present rootstock experiment there was an opportunity to determine the degree of influence of exocortis and xyloporosis viruses on the size of trees on susceptible rootstocks in the orchard; additional evidence on the influence of these viruses was provided by virus-indexing tests.

MATERIALS AND METHODS

Propagation and Care of Orchard Trees

The budwood used in propagation of trees in the rootstock orchard came from a high-yielding grove of 20-year-old Valencia orange trees on sour orange rootstock. Some trees in the grove are infected by psorosis virus, but others are registered as psorosis-free by the Texas Department of Agriculture. There is no record as to the particular trees used as budwood sources in propagation of the rootstock orchard. The occurrence of psorosis leaf symptoms in some budded progeny in the rootstock planting suggests that some budwood came from non-registered and psorosis-infected trees.

The rootstock seedlings were budded during 1948 and 1949 and the budded trees were set out in 1950 at a 25 x 25 feet spacing. The trees were frozen to the banks of earth around the trunks during the winter of 1950-51 but comparatively few died.

The comparative size of a tree is fairly well indicated by the area of a cross-section of its trunk (Webber, 1932). Each tree trunk, 4 inches above the bud union, was measured in April, 1956. Each year since 1952 every tree was carefully inspected for symptoms of exocortis and xyloporosis.

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations, sponsored jointly by the Texas Agricultural Experiment Station and the U. S. Department of Agriculture, with Rio Farms, Inc., cooperating.

Virus-Indexing Tests

In January, 1953, we grafted buds from six different Valencia orange trees (from the bud-source grove already described) on nine rootstocks, some of which are sensitive to known viruses. We used the sour orange and Cleopatra mandarins because they are commercially important in Texas; Butwal sweet lime and Sunshine tangelo as xyloporosis indicators; Morton citrange and Rangpur mandarin-lime as exocortis indicators; Rough lemon because it is commercially important in Florida; Rustic citrange and Webber tangelo because they seemed relatively tolerant to exocortis and xyloporosis, respectively.

One progeny tree of each bud-source on Butwal sweet lime, and two progeny trees of the remaining scion-rootstock combinations were set in the field at a 14 x 5 feet spacing in November, 1953. Forty-two months after budding these trees were examined for evidence of exocortis and xyloporosis diseases on the rootstock. The tree trunks, 4 inches above the bud union, were measured at the same time.

Identification of Diseases in Rootstock Orchard and in Virus-Indexing Test

Xyloporosis, as used in this report, describes inner bark disorders associated with pits in the wood, pegs from the inner bark, and sometimes a brownish to orange gum stain in the inner bark (Reichert and Perlberger, 1934). The small brown to orange spots in the inner bark, which are pronounced in affected tangelo or mandarin trees, are either not present or much less marked in xyloporosis-affected sweet lime rootstocks (Childs, 1956).

Exocortis, as used in this report, describes bud-transmitted bark-shelling disorders that begin at or near the ground line. Rootstocks susceptible to this disorder include *Poncirus trifoliata* (Benton et al, 1950) some of its hybrids (Bitters, 1952), and the mandarin-limes (Moreira, 1955; Olson and Shull, 1956).

Bud union crease, a disorder of unidentified cause, is characterized by a gumming of inner bark at the bud union and a separation of the outer bark at the bud union (Olson, 1954). The relation, if any, to exocortis and xyloporosis has not been determined.

Psorosis symptoms in the foliage consist of characteristic fleckings in the new flush leaves (Fawcett, 1936).

RESULTS

Size and Disease Status of Trees in Rootstock Orchard

As shown in Table 1, 6-year-old xyloporosis- and exocortis-infected trees were generally smaller than apparently disease-free trees on the same susceptible rootstocks.

Some rootstocks not included in Table 1 have shown no recognizable symptoms of exocortis or xyloporosis when budded trees were grown under orchard conditions for 6 years. They include the following: Bergaldin (a calamondin x sour orange hybrid); Rusk, Sanders and Savage citranges; citron; Webb Red Blush and Duncan grapefruit; Changsha, Cleopatra, Kara, King and Ponkan mandarins; Chinotto and Florida sour oranges; Gzel Gzel, Louisiana Sweet, Parson Brown, Pineapple, and Valencia sweet oranges; Sampson, San Jacinto, Watt, Webber and Williams tangelos; Natsumikan; African shaddock and Rough lemon. There are 2 possible explanations for the lack of visible symptoms on these rootstocks: (a) the trees carry the viruses but the rootstocks are tolerant, (b) the trees may not carry the viruses. However, in view of the data in Tables 1 and 2, it is probable that many of these trees do carry exocortis and xyloporosis viruses and the rootstocks are tolerant of them.

Table 1. Comparative size[1] and disease status of 6-year-old Valencia orange trees on various rootstocks.

Rootstock	*Trees with apparently healthy rootstock*		*Trees with affected rootstock*			*Tree size[1] decreased by disease*
	No.	*Cross-sectional area[1]*	*Disease*	*No.*	*Cross-sectional area[1]*	
		square inches			*square inches*	*percent*
Mandarin-limes:						
Kusaie	2	22.0	Exocortis	9	8.5	61.4
Rangpur	6	18.8	Exocortis	3	11.3	40.0
"Rose lemon"	9	22.9	Exocortis	3	13.8	39.7
Morton Citrange	4	17.3	Exocortis	1	6.6	61.8
Poncirus trifoliata	2	14.5	Exocortis	1	6.1	57.9
Columbian sweet lime	5	18.8	Xyloporosis	5	8.5	54.8
Leonardy grapefruit	3	17.3	Xyloporosis	3	15.9	8.1
Mandarins:						
Chou Choo Tien Chieh	4	16.6	Xyloporosis	7	9.1	45.2
Satsuma	6	19.6	Xyloporosis	6	13.8	29.6
Tangelos:						
D-14-C	7	24.6	Xyloporosis	2	15.2	38.2
Minneola	6	18.8	Xyloporosis	6	11.9	36.7
Orlando	1	23.7	Xyloporosis	5[2]	7.1	70.0
Seminole	3	16.6	Xyloporosis	1	8.0	51.8
Sunshine	5	18.8	Xyloporosis	3	18.1	3.7
Thornton	3	15.9	Xyloporosis	7	12.6	20.8
Yalaha	6	13.2	Xyloporosis	4	11.9	9.8
Altoona tangor	8	18.1	Xyloporosis	2	9.1	49.7

[1] Size is indicated by the area in square inches of a cross-section of trunk 4 inches above the bud union.

[2] 3 additional trees killed by xyloporosis.

This list of possibly tolerant rootstocks is in general agreement with the list of exocortis- and xyloporosis-tolerant rootstocks for red grapefruit described by Cooper, Olson, Maxwell and Otey. On trees with red grapefruit tops, these authors report that Williams tangelo and Natsumikan rootstocks showed bark-shelling symptoms similar to those caused by exocortis; Williams tangelo and Changsha mandarin rootstocks showed xyloporosis symptoms; and the Rough lemon rootstocks showed a brown inner bark strain similar to that caused by xyloporosis.

In some instances, every tree on a rootstock variety has shown evidence of a rootstock disorder. Bud union crease, a disorder of unidentified cause, occurred on all trees with calamondin and lemonquat rootstocks. Xyloporosis occurred on every Dancy mandarin rootstock, except one small tree, and on every Cuban shaddock rootstock.

Size and Disease Status of Trees in Virus-Index Tests

The budded progenies of 3 trees (1-19, 4-16 and 2-20 in the budwood source orchard) were free of visible symptoms of psorosis, exocortis and xyloporosis; the budded progeny of one tree (8-21) was free of visible symptoms of psorosis but carried exocortis and xyloporosis viruses; the budded progenies of 2 trees (4-21 and 6-17) showed psorosis leaf symptoms in the orange foliage but no recognizable symptoms of exocortis and xyloporosis in susceptible rootstocks.

The budded progeny trees with only psorosis symptoms were of the same size or smaller than those free of psorosis, exocortis and xyloporosis virsuses (Table 2).

In a comparison of psorosis-free trees budded on the same rootstock, those with exocortis and xyloporosis symptoms were stunted in varying degree when grown on susceptible rootstocks (Table 2).

Thus, some bud-source trees in the bud-source grove are free of three recognized bud-transmitted viruses, while other trees in the same grove carry one or more of them. The variation in virus status of the bud-source trees probably explains the variability in size and rootstock disease status of the budded trees in orchard tests on virus-sensitive rootstocks.

DISCUSSION

Virus-indexing of bud-source trees has several possible uses in citrus rootstock studies. First, virus-indexing can identify certain bud-transmitted viruses causing erratic behavior in rootstocks in existing plantings. The present report on Valencia orange scions is based upon such usage of virus-indicator rootstocks. Second, virus-indexing techniques make it possible to screen several potential budwood-source trees and eliminate those with recognized bud-transmitted viruses. Such procedure eliminates bud-transmitted viruses as a factor in determining the adaptability of rootstocks to local conditions. Where insect-transmitted viruses like tristeza are involved, elimination of other bud-transmitted viruses in the budwood source reduces the confusion in determining rootstock tolerance to the insect-transmitted virus.

Virus-indexing of bud-source trees is also of interest to the grower. This type of test in Florida (Childs et al, 1955) indicated the high incidence of xyloporosis in certain Florida citrus varieties under test as budwood-source trees. However, the effect of exocortis and xyloporosis viruses on the horticultural characteristics of trees grown on tolerant rootstocks, such as sour orange, is yet to be determined.

SUMMARY

Six years after planting, Valencia orange trees on each of 17 rootstocks fell into two general groups; one with larger trees and apparently free of recognizable symptoms of bud-transmitted rootstock diseases; the other with smaller trees with either exocortis or xyloporosis symptoms on the rootstock. Other rootstocks were either free of recognizable bud-transmitted rootstock disorders or every tree on a single rootstock variety showed a rootstock disorder. Occasional trees with leaf symptoms of psorosis occurred in the planting.

While the particular trees used as budwood sources for the rootstock orchard planting are not known, 6 trees were selected from the grove where the original budwood was collected. When propagated on virus-indicator rootstocks, the 6 trees fell into 3 groups: 2 trees with psorosis virus alone; 1 tree with exocortis and xyloporosis viruses; and 3 trees which were free of psorosis, exocortis and xyloporosis. Forty-two months after budding, the trees with psorosis alone were the same size or slightly smaller than comparable psorosis-free trees; exocortis- and xyloporosis-infected trees were smaller than comparable trees free of these 2 viruses. The effect of virus on tree size varied with the rootstock. On the basis of these results from the virus-indexing tests, it was concluded that variations in virus content of the original budwood was reflected in size of orchard trees grown on virus-sensitive rootstocks.

Table 2. Size[1] and disease status of Valencia orange trees on various rootstocks[2], 42 months after budding from 6 bud-source trees.

Rootstock	*Trees with apparently healthy rootstock*		*Trees with affected rootstock*		*Size[1] decreased by disease in psorosis-free trees*
	Cross-sectional area[1] of psorosis-free trees[3]	*Cross-sectional area[1] of psorosis-infected trees[4]*	*Disease*	*Cross-sectional area[1] of psorosis-free trees[5]*	
	square inches	*square inches*		*square inches*	*percent*
Butwal sweet lime	4.9	4.5	Xyloporosis	1.5	69
Cleopatra mandarin	2.5	2.3	None	2.3	11
Morton citrange	2.5	2.3	Exocortis	1.1	55
Rangpur mandarin-lime	5.3	4.1	Exocortis	3.1	41
Rough lemon	3.1	3.1	None	3.1	0
Rustic citrange	2.8	2.3	None	1.8	38
Sour orange	2.5	2.5	None	2.5	0
Sunshine tangelo	2.5	2.5	Xyloporosis	2.3	11
Webber tangelo	3.1	2.0	None	3.1	0

[1] Tree size is indicated by area in square inches of a cross-section of trunk, 4 inches above the bud union.

[2] There were 2 trees of each bud-source–rootstock combination except those with Butwal sweet lime rootstock, which had only 1 progeny tree of each of the 6 bud-source trees tested.

[3] Budded progeny of trees 1-19, 4-16 and 2-20.

[4] Budded progeny of trees 4-21 and 6-17.

[5] Budded progeny of tree 8-21.

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Mesophyll Collapse and Defoliation of Grapefruit Leaves Following Cold Dry North Winds in the Rio Grande Valley of Texas[1]

E. O. Olson and W. C. Cooper

SYMPTOMS OF MESOPHYLL COLLAPSE

Mesophyll collapse is characterized by collapsing and drying of soft interior tissues (mesophyll) on the underside of citrus leaves (Figure 1, A, B, C). This disorder was described by Fawcett (19[illegible]6) and Haas (1937). One or several separate places on a single leaf blade, often bounded by two main lateral veins, turns yellow and dries out, but sometimes the places turn light gray or brown. Affected areas may be invaded by fungi. The cells in the affected tissue of the spots are dead or drying; some dry out and collapse and others enlarge. Tissues on the upper side of the leaf are unaffected in the early stages of the malady, but eventually they die and dry following the collapse, death and drying of the mesophyll tissue. Mesophyll collapse has been observed in California, Florida, Arizona, Texas, Mexico and South America (Turrell et al. 1943). This article presents observations on the effect of rootstock and soil moisture on occurrence of mesophyll collapse in the Rio Grande Valley of Texas, reports the prevailing local opinion as to its cause, and compares this with opinions from California, Arizona and Florida.

OCCURRENCE OF MESOPHYLL COLLAPSE IN THE RIO GRANDE VALLEY

Mesophyll collapse commonly occurs in late fall or early winter in commercial groves of sweet orange and grapefruit trees. The malady develops soon after the arrival of a "dry norther," a cold north wind with low relative humidity. North winds of the same velocity and temperature but of high relative humidity do not cause the disorder. After a dry norther the foliage on some branches, particularly on the north side and tops of the trees, may dry, curl up and drop in varying degrees (Figure 1 D). Foliage on some branches show mesophyll collapse before defoliation; on other branches some leaves drop before they show the disorder, but remaining leaves may develop mesophyll collapse later. Defoliation and mesophyll collapse are most common on the last 2 flushes of growth. Sometimes leaves of the last flush will drop. On other occasions, only a few leaves of the last flush show mesophyll collapse, while most leaves on the preceding flush on the same branch either develop mesophyll collapse and defoliate, or defoliate before mesophyll collapse is noted.

[1] These investigations are part of the Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the United States Department of Agriculture. The cooperation of Rio Farms, Inc., Monte Alto, of Harold Randle, Mission, and of P. W. Rohrbaugh, Weslaco, is greatly appreciated.

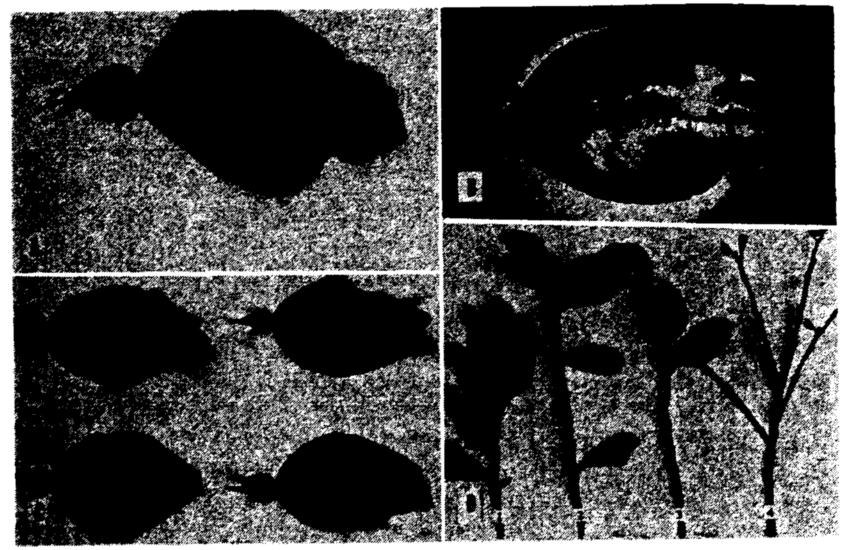

Figure 1. A-C, mesophyll collapse and defoliation on grapefruit leaves following a dry norther in the Rio Grande Valley. A, greyish collapsed area of under surface of leaf as seen in direct light; B, same leaf showing yellow area surrounding the collapse area in transmitted light; C, leaves showing various patterns of mesophyll collapse in direct light. The edges of the collapsed area have corked over and fungi have invaded some portions of the collapsed area. D. Grapefruit twigs showing mesophyll collapse, defoliation or both: 1, last flush; 2, last two flushes; 3, last two flushes with next-to-last completely defoliated; 4, complete defoliation of the last two flushes.

Foliage on branches protruding from the main canopy, and thus more exposed to the wind, is particularly susceptible. Foliage on trees exposed to direct force of the wind, such as those on the north side of a grove or along roadways which funnel air currents, is generally injured more than foliage on trees protected from the wind. Young replants in a grove of old trees usually show less mesophyll collapse than do bigger trees, whose tops are exposed to the full force of the wind.

The injury to the leaves and the loss of foliage occur quickly and are of concern to the grower. Defoliated branches may die back, develop a weak new flush of growth or remain apparently dormant for several months. Growers fear that the foliage loss may reduce fruit size of the current crop and adversely affect the next year's crop.

In spite of the sudden appearance of injured leaves associated with defoliated and dying branches, there is no evidence that the disorder is an infectious disease caused by a fungus, bacterium or virus. Schulz (1947) noted that the air of a dry norther may have a humidity of 12 to 14 per cent compared with an average of 66 per cent, and water is extracted from the leaves many times as fast as usual. He observed that when sufficient moisture is present in the soil and the trees have plenty of healthy roots to absorb it, the trees show relatively less defoliation.

The effect of a dry norther is like that of a drouth, causing sudden and extreme water losses (Schulz, 1947). Friend (1946) noted that thousands of Rio Grande Valley trees growing in dry and slightly saline soils suffered severe loss of foliage and fruit in a windstorm in January, 1946; trees having adequate moisture suffered little or no damage.

MESOPHYLL COLLAPSE AND DEFOLIATION IN THE RIO GRANDE VALLEY DURING NOVEMBER AND DECEMBER, 1956

From November 9 to 23, 1956, three separate dry northers blew into the Rio Grande Valley (Table 1). These north winds brought in air characterized by low relative humidity, low temperatures and occasional gusts of over 30 miles per hour velocity. By late November, partial defoliation and mesophyll collapse were common in many commercial citrus groves. In order to determine whether rootstocks and certain cultural treatments affected the incidence of the disorder, grapefruit trees in various experimental plantings in the Rio Grande Valley were examined.

Mesophyll collapse was relatively unimportant in a rootstock planting at Delta Lake; this planting of Shary Red grapefruit had received a recent irrigation with water of good quality and was protected on the north and west sides by windbreaks, and rust mite and scale damage were not evident in it. However, 2 other rootstock plantings showed varying degrees of damage from mesophyll collapse and leaf dessication. One consisted of 9-year-old Webb Red Blush grapefruit trees with no windbreak protection, the trees had been irrigated with salty well water and the foliage showed evidence of damage by scale and rust mite. In this orchard, trees on Rangpur mandarin-lime and Rough lemon rootstocks showed less mesophyll collapse than those on sour orange or other rootstocks (Table 2).

The second rootstock orchard showing mesophyll collapse consisted of 4 replications of 4-year-old trees of Webb Red Blush grapefruit arranged in 2- or 3-tree blocks. The orchard had no windbreak, had been irrigated with good-quality water, and showed some rust mite damage

Table 1. Climatological data for selected days at Weslaco, Texas.

	Specific days in November, 1956										
Atmospheric condition	8	9	10	11	12	13	16	17	21	22	23
Prevailing wind direction	NE	NE	N	SE	SE	SE	NE	NE	N	NE	SE
Temperature maximum (°F.)	75	69	74	84	84	82	63	65	69	71	79
Temperature minimum (°F.)	66	47	38	43	53	57	53	53	53	42	46
Relative humidity (percent) at 8 AM	80	48	67	50	87	93	54	30	33	36	72
Relative humidity (percent) at 5 PM	34	18	12	40	33	60	22	42	8	12	44
Lowest humidity for 24 hours	32	16	12	28	26	52	20	26	8	12	36
Total wind movement, miles in 24 hrs.	94	69	20	49	52	62	112	55	101	44	35
Maximum wind velocity, miles per hr.	34	20	11	21	18	27	31	19	37	22	21
Evaporation, actual amount in inches	.20	.27	.19	.19	.14	.18	.26	.21	.28	.24	.14

but no scale damage. Trees on Rough lemon or some mandarin rootstocks were affected less than those on sour orange or Cleopatra mandarin rootstocks (Table 3).

Other experimental plantings of red grapefruit were also available for inspection. One planting consisted of 1- and 2-year-old trees on Cleopatra mandarin, sour orange and Rough lemon rootstocks under replicated tests to determine the effect of soil moisture levels on winter dormancy and cold hardiness. The soil of some plots had been irrigated once a week beginning October 1; the soil of other plots had received no irrigation water or rain since October 1. The trees were planted in 4-tree plots. The trees grown on dry soil had more defoliated shoots than the "wet" trees, fewer remaining on the shoots, and a higher per cent of mesophyll collapse on the remaining leaves (Table 4). The foliage of grapefruit trees on Cleopatra mandarin rootstock had as much injury as the foliage of those on sour orange rootstock; trees on Rough lemon rootstock were affected less than adjacent trees on Cleopatra mandarin (Table 4).

Another experimental planting consisted of Webb Red Blush grapefruit on sour orange and Cleopatra mandarin rootstocks irrigated with water containing varying kinds and amounts of salt. The trees were given different salt treatments for 3 years. During this period leaves were observed for symptoms of salt toxicity. Each fall and winter following "dry northers," the trees were inspected for specific symptoms of mesophyll collapse. In no instance were differences observed in the incidence of mesophyll collapse on control trees irrigated with river water con-

Table 2. Defoliation[1] of 9-year-old trees of Webb Red Blush grapefruit on various rootstocks in December following dry northers in November 1956.

Rootstock group or variety	*Varieties*	*Trees in test*	*Defoliation index*[2]
	Number	Number	
Sweet oranges	2	7	2.4
Sour oranges	5	48	2.5
Mandarins	5	54	2.5
Tangelos and tangors	12	116	2.3
Calamondin	1	9	2.2
Grapefruit	2	21	1.9
Natsumikan	1	7	2.3
Rangpur mandarin-lime	1	11	1.5
Rough lemon	1	11	1.6
Shaddock	1	12	2.1
Thong Dee	1	10	2.1

[1] Varying amounts of mesophyll collapse were present in foliage remaining on the trees.

[2] Index used: 0, no defoliation;
1, occasional defoliation on north side;
2, general defoliation of terminal growth on north side;
3, general defoliation of tops and north side;
4, general defoliation of all sides of the tree.

taining 600 ppm total salts and trees irrigated with water containing 4000 ppm NaCl, 4000 ppm Na_2SO_4, or 4000 ppm NaCl + $CaCl_2$. The chemical analysis of these leaves, however, showed marked differences in chlorides, sulfates, sodium and calcium and slight differences in magnesium.

P. W. Rohrbaugh, Weslaco, is studying the influence of cultural practices on the growth and yield of red grapefruit. The plots consist of 4-year-old red grapefruit trees grown under 7 different weed control systems: shallow occasional cultivation; deep occasional cultivation; no cultivation, rotary shredder used; frequent deep cultivation; no cultivation, chemical weed control; no cultivation, legume cover crop; and no cultivation, gin trash added. Trees grown in soil mulched with gin trash, composed of cotton boll hulls and other residues from cotton ginning, had fewer leaves with mesophyll collapse and fewer defoliated branches than the trees in the other treatments. There was also more moisture in the soil under the gin-trash mulch treatment, compared with those in the other 6 treatments.

Table 3. Defoliation and mesophyll collapse[1] of 4-year-old Webb Red Blush grapefruit trees on various rootstocks, December 1956.

Rootstock group or variety	*Leaves defoliated*	*Leaves with mesophyll collapse*	*Total injured foliage*
	percent	percent	percent
Grapefruit:			
Duncan	3	21	24
Red Blush	4	29	33
Red Blush (unbudded seedling)	9	29	38
Mandarins:			
Changsha	2	8	10
Cleopatra	20	34	54
Dancy	4	31	35
False hybrid satsuma	7	25	32
Kinnow	13	37	50
Meune Shu Chang[2]	1	5	6
Miray	7	21	28
Shekwasha	5	14	19
Silverhill satsuma	3	28	31
Suenkat	6	27	33
Sun Chu Sha Kat	12	37	49
Rough lemon	2	14	16
Sour orange	13	38	51
Sweet orange (Sanguinea)	7	21	28
Tangelos:			
Pearl	21	26	47
Williams	12	21	33
Trifoliate hybrids:			
Citrangeuma	4	27	31
Norton citrange	7	23	30
Sacaton citrumelo	5	26	31
Savage citrange	4	24	28

[1] Defoliation and mesophyll collapse values were based on visual estimates of damage to the top half of the foliage canopy. The values recorded are the means of estimated damage to the last two flushes on 8 to 12 trees on the indicated rootstock.

[2] Many of the trees on this rootstock were chlorotic.

MESOPHYLL COLLAPSE IN OTHER STATES

In California, Fawcett (1936) and Haas (1937) considered that mesophyll collapse occurred under conditions where the tree had difficulty in conducting an adequate supply of water to the leaves. Contributing conditions listed by them included dry north winds (Fawcett, 1936) and humid or dry winds (Haas, 1937). Other Californians considered that mesophyll collapse was related to mite damage or to physiological unbalance of certain salts in the leaves; these opinions are discussed later.

In the Coachella Valley of California, J. B. Carpenter (unpublished data, U. S. Field Station, Indio) followed the progress of mesophyll collapse in a semi-hedge planting of red grapefruit. The planting includes 3-year-old trees on Cleopatra mandarin rootstock and 2-year-old trees on Rough lemon rootstock. The prevailing winds are from the north in the Coachella Valley and a moderately strong wind preceded the occurrence of mesophyll collapse in this planting in October and November 1956. Leaf damage and defoliation were present on the north side of nearly all of the grapefruit trees on Cleopatra mandarin rootstock, while those on Rough lemon rootstock suffered little or no damage. Many of the trees on Cleopatra mandarin rootstock lost more than one-third of their

Table 4. Defoliation and mesophyll collapse of 1- and 2-year-old Webb Red Blush trees in dry and wet soil in December following dry northers

Tree age and kind of soil	*Rootstock*	*Trees*	*Shoots defoliated*[1]	*Leaves remaining*[2]	
				Total	*With mesophyll collapse*
		Number	Percent	Number	Percent
2-YEAR-OLD GRAPEFRUIT TREES					
Dry	Sour	4	53	33	58
Dry	Cleopatra	4	55	30	70
Wet	Sour	4	2	45	13
Wet	Cleopatra	4	3	45	13
Dry	Cleopatra	4	61	31	74
Dry	Rough lemon	4	1	48	13
1-YEAR-OLD GRAPEFRUIT TREES					
Wet	Sour	7	9	47	6
Dry	Sour	8	7	28	29

[1] Shoots showing partial or complete defoliation.

[2] Based on leaf counts of 4 samples per tree, consisting of the most recent flush shoots, approximately 8 inches in length.

foliage and extensive dieback of defoliated branches is expected.

In Arizona, Hilgeman and Van Horn (1955) reported that mesophyll collapse frequently develops during late September, October and early November. The injury appears to be caused by dry winds of medium-velocity which may not last long. Irrigating during the time the wind is blowing tends to increase rather than decrease the damage. The general condition of the trees affects the susceptibility to injury; trees grown with ample water and heavy nitrogen fertilization have been much more severely damaged than trees not heavily fertilized or not irrigated frequently during late summer. Grapefruit trees growing under alfalfa hay mulches have always been the most severely damaged. Trees under Bermuda grass sod culture usually have the least damage.

In Arizona, spraying trees with 2, 4-D nutritional sprays and insecticides to control mites has not reduced the injury. Species differ in susceptibility usually in the following increasing order of resistance: grapefruit, orange, tangerine and lemon (Hilgeman and Van Horn, 1955).

In Florida, information on the occurrence of mesophyll collapse was provided by F. E. Gardner and P. F. Smith, U. S. Horticultural Field Station, Orlando. They considered that mesophyll collapse in Florida has a different pattern of occurrence than that in Texas, Arizona or California. The disorder is most common in May and June when it is hot and dry and is relatively less common in the fall and winter. However, almost every year during November or December a north-easterly wind blows for a day or two; this cold wind is drier than normal and causes leaf roll and defoliation on the northeast side of the tree. In these instances, some leaves remaining on partly defoliated branches will later develop mesophyll collapse. Foliage with mesophyll-collapse symptoms resulting from early summer injury is more prone to early-winter defoliation than uninjured foliage. The most severe cases of mesophyll collapse are encountered in summer inspections of leaves badly etched by red mites. Mesophyll collapse is rare on grapefruit, but common on oranges, especially the Temple "orange."

POSSIBLE CAUSES OF MESOPHYLL COLLAPSE

Observations in the Rio Grande Valley indicate that the kind of rootstock may influence the susceptibility of grapefruit foliage to mesophyll collapse (Tables 2, 3, 4). They also confirm unpublished observations of J. B. Carpenter who noted that in the Coachella Valley trees on Rough lemon developed less mesophyll collapse than those on Cleopatra mandarin rootstock. If mesophyll collapse is initiated by cold dry winds, rootstocks that supply enough water to the leaves to offset the transpirational stress caused by low humidity, low temperature and high winds may contribute to a lower incidence of mesophyll collapse and defoliation of grapefruit.

As shown in Table 4, trees grown on dry soil are more susceptible to the disorder than those grown on wet soil. Higher soil moisture levels under trees mulched with gin trash may explain the lower incidence of mesophyll collapse, than on trees in drier soil with other weed control

systems. These observations in the Rio Grande Valley are in partial agreement with observations of Fawcett (1936), who considered that mesophyll collapse occurred under conditions where the tree had difficulty in conducting an adequate supply of water to the leaves. Fawcett (1936) considered dry north winds one of several contributing conditions but growers in the Rio Grande Valley consider that dry northers are the primary cause of mesophyll collapse.

In California, trees growing under optimum soil- and air-moisture conditions and subjected to occasional severe water deficits generally show the greatest incidence of mesophyll collapse, while trees continually subjected to water deficit are least affected (Turrell et al. 1943). In the Rio Grande Valley, the relation of occasional versus sustained water stress to mesophyll collapse is not clear. In California groves observed by Turrell et al. (1943), leaves showing mesophyll collapse were found on only the north side of the tree, or distributed generally around the trees. Turrell et al. (1943) regarded the disorder as a disturbance of the leaf caused by unbalance in the distribution of calcium, magnesium, potassium and sodium; they did not explain why such an unbalance is common on the north side of the tree. Nor does such a nutritional unbalance explain the widespread occurrence of mesophyll collapse on the north side of trees in California, Florida, Arizona and Texas. However, the effects of dry north winds would be most apparent on the north side of the tree. Fawcett (1936) considered saline soil as a contributing factor, but Sokoloff et al. (1943) considered the disturbances caused by excessive salts to resemble only superficially mesophyll collapse. In the Rio Grande Valley, soil salinity causes different symptoms which occur gradually during the summer, while mesophyll collapse occurs suddenly following a cold dry north wind in fall or winter. In the Rio Grande Valley, marked differences in accumulation of various salts in the leaves induced by irrigation with various salts did not affect the incidence of mesophyll collapse.

The presence of citrus red mites, *Paratetranychus citri* (McG.), was considered a contributing factor by Fawcett (1936). Ebeling (1950) noted that hot dry winds accentuate defoliation when mites are present. Sokoloff et al. (1943) considered that red mite was neither a forerunner nor a necessary accompaniment of mesophyll collapse. Rust mites, *Phyllocoptruta oleivora* (Ashm.), were considered contributing factors in California by Fawcett (1936) and Ebeling (1950) and in Florida by Thompson (1946). Thompson noted, however, that mesophyll collapse occurred in groves where neither rust mites nor red mites were found. *P. citri* (McG.) has never been found in the Rio Grande Valley, where the Texas citrus mite, *Eutetranychus clarki* (McG.) is common (Dean, 1952). The relation of mite injury of the leaf to mesophyll collapse has not been studied in the Rio Grande Valley, but leaves affected by mesophyll collapse may show injury from *E. clarki* mite.

Desiccation by cold dry winds would be expected to injure the mesophyll cells in the lower leaf surface before injuring the upper surface of the leaf, since Haas and Halma (1932) reported that the under surfaces of Marsh grapefruit and Valencia orange leaves transpired 2 to 3 times as much water as did the upper leaf surface, which contained no stomata. Their experiments were conducted under glasshouse conditions with solution cultures and presumably in the absence of cold, drying winds.

Observations in Arizona (Hilgeman and Van Horn, 1955) and in the Rio Grande Valley indicate that the leaves at the tip of the shoot often are undamaged, while older leaves are injured by mesophyll collapse. Reed and Bartholomew (1930) showed that young leaves lose water more slowly than leaves from older growth cycles. Thus, an effect of leaf age on the incidence of mesophyll collapse is in agreement with the theory that the injury is caused by desiccation.

In Arizona winds of greater velocity, less humidity and higher temperatures occur frequently in July and August without causing damage; the same is true of winter winds which occur infrequently and of the normal spring winds which may blow for 12 hours at a time. The injury in Arizona appeared to be caused by dry winds of medium-high velocity which may last for periods as short as 3 hours (Hilgeman and Van Horn, 1955). These observations are in agreement with those in the Rio Grande Valley, and suggest that a sudden drop in the relative humidity of the air favors susceptibility to mesophyll collapse. Nigam (1932) in limited laboratory tests of *Citrus medica* (in India) showed that a sudden decrease in air humidity caused severe collapse of leaf tissue from sun scorch; no collapsed tissue developed in plants kept at low humidity or in those shifted gradually from high to low humidity.

PREVENTION OF MESOPHYLL COLLAPSE AND DEFOLIATION BY DRYING WINDS

The obvious prevention is to bring about conditions under which the tree can get more water to the leaves in times of stress. Reed and Bartholomew (1930) concluded that a large part of the damage from desiccating winds in California could be avoided by cultural and irrigation practices that promote water penetration in the soil, full development of the rooting system of the trees, and adequate soil moisture. However, in Arizona, irrigating during the time the wind is blowing tended to increase rather than decrease the damage from mesophyll collapse. As shown in Table 4, maintaining the soil moisture at levels at which the leaves get adequate water reduced the incidence of mesophyll collapse even when rapid water loss occurs during dry northers; trees grown in soil mulched with gin trash, which conserved water in the soil, showed less defoliation and mesophyll collapse than those grown in drier soil. Since mite damage may predispose the leaves to more desiccation injury from cold, drying winds, measures to control mites will be helpful.

The use of wind breaks to reduce wind velocity in the groves also has received increasing attention in recent years.

Another possibility is the use of Rough lemon or Rangpur mandarin-lime rootstocks. However, under Rio Grande Valley conditions Rough lemon rootstock produces grapefruit slightly inferior in quality to that

produced by trees on sour orange rootstock, especially late in the season. The Rangpur mandarin-lime rootstock, subject to various bud-transmitted disorders, is still under test and is not yet recommended for commercial use in Texas.

SUMMARY

Three different periods of cold dry north winds occurred in the Lower Rio Grande Valley of Texas in November 1956. By December, partial defoliation of branches and mesophyll collapse were common in the tops and north sides of grapefruit and sweet orange trees in commercial groves. In experimental plantings, young grapefruit trees on Rough lemon and some mandarin rootstocks showed less damage than those on Cleopatra mandarin, sour orange and other test rootstocks. Young grapefruit trees on Cleopatra mandarin and sour orange rootstocks showed more defoliation and mesophyll collapse on dry soils than on wet ones.

Local growers consider that cold dry north winds cause mesophyll collapse in susceptible trees. This opinion is compared with opinions reported from Florida, California, and Arizona.

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Some Species of Ants in the Citrus Grove and Their Control

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Ants do a considerable amount of damage to citrus trees in the Lower Rio Grande Valley each year. Losses result from the direct feeding of some species upon the foliage and bark of young trees, and indirect losses by interfering with the efficiency of parasites and predators in the natural control of scale insects. Tests were conducted in 1955 and 1956 to determine the effectiveness of chlordane, heptachlor and dieldrin applied as dusts, granules or sprays for the control of the fire ant, the harvester ant and the acrobatic ant.

THE FIRE ANT

Literature Review: The fire ant, *Solenopsis geminata* (Fabr.), may cause severe injury to young citrus trees in the Lower Rio Grande Valley. It has been reported as feeding on citrus in Porto Rico, California, Arizona by Essig (1930) and Texas by Clark (1931). Ebeling (1949) reported this species as a serious pest of young avocado trees in California. Its food consists of portions of various plants including leaves, twigs and bark as well as honeydew secreted by scale insects, aphids and mealybugs. While attending honeydew-producing insects the fire ant attacks the natural enemies of nearly all insect pests affecting citrus. Morrill and Otanes (1947) found that a mealybug buildup following a DDT spray application was assisted by the fire ant. Roberts (1946) stated that if ants are controlled, the parasites and predators will keep aphids, scale insects, white flies, and thrips pretty well under check.

Early control measures for the fire ant consisted either of fumigants or poison baits. Tests by Clark (1931) showed calcium cyanide dust was the cheapest and most effective fumigant. However, two applications were required to obtain complete control.

Thallium sulfate was recommended in poison baits for ants by Popenoe (1926). It was first recommended for use against the fire ant by Essig (1930). Tests by Clark (1931) showed it to be very effective against fire ants when used at the rate of 2 oz. thallium sulfate per gallon of sugar syrup bait.

Organic insecticides were found to be effective against this species of ant by Roberts (1946). He recommended one-quarter to one-half teacup of 5 to 10 per cent BHC or Dianisyl Trichloroethane raked into the nest for control of the fire ant.

Field Studies: Tests were conducted in a citrus grove near Monte Alto during the fall 1955 and spring 1956. Insecticides which were used are listed in Table 1.

Each ant mound was treated with 65 to 85 grams of insecticide and marked for future observation. Each material was evenly distributed on the mound and in a 4-inch band around the perimeter of the mound. A one-pound coffee can with holes punched in the bottom was used in distribution. The ant mound was not disturbed except to check for an active colony. Records were taken two and six weeks following treatment. The nests were probed with a sharp stick after two-week intervals and dug up to a depth of ten inches after six weeks. A total of 443 ant nests was treated in the fall and 300 in the spring tests.

Results: The data in Table 1 show that dust and granulated formulations of chlordane, heptachlor, and dieldrin resulted in comparable control of the fire ant. Spring treatments proved more effective than the fall treatments. In the fall test granulated materials gave comparable control and were slightly better than the dust formulations. Chlordane dust applications resulted in slightly better control than heptachlor or dieldrin dusts. In the string test all materials resulted in complete control except in the case of dieldrin dust.

THE TEXAS HARVESTER ANT

Literature review: The Texas harvester ant, *Pogonomyrmex barbatus* var. *malefaciens* (Buckl.), is noted for its habits of denuding large areas of vegetation and inflicting painful stings to workers in citrus groves. The harvester ants clean all vegetation from the ground around their nests

Table 1. Control of fire ants with dusts and granulated materials.

Treatment (1 application)	*Colonies treated*	*Percent colonies controlled at end of the period indicated*	
		2 weeks	*6 weeks*
	Fall Test 1955		
Chlordane			
10% Dust	80	97.5	97.5
5% Granulated	56	92.9	98.3
Heptachlor			
2.5% Dust	68	94.1	90.7
2.5% Granulated	64	95.3	98.7
Dieldrin			
2.5% Dust	97	78.4	90.7
5% Granulated	81	91.4	98.5
	Spring Test 1956		
Chlordane			
10% Dust	50	100.0	100.0
5% Granulated	50	100.0	100.0
Heptachlor			
2.5% Dust	50	96.0	100.0
2.5% Granulated	50	100.0	100.0
Dieldrin			
2.5% Dust	50	92.0	98.0
5% Granulated	50	100.0	100.0

and use the seeds for food. This is particularly objectable in permanently sodded groves. In fields subject to frequent cultivation the harvester ant normally does little damage; however, in established groves, where proper control measures are not practiced, the ants may increase rapidly.

Young citrus trees have been known to be killed by the harvester ant. Nichol (1931) reports 2-and 3-year old trees killed by this species in Arizona. The trees were particularly attacked under clean-cultivated conditions when trees were planted on newly cleared land which was heavily infested by the harvester ant.

The organic insecticidal sprays and dusts have to a large extent replaced the fumigants and ant powders which were formally used for control of the harvester ant. Wildermuth and Davis (1931) obtained good control by the use of carbon bisulfide and London purple.

Brett and Rhodes (1946) found three per cent chlordane sprays poured into the ant nest effective against the harvester ant. Carbon tetrachloride and 95 per cent alcohol were used as solvents.

Riherd (1948) obtained some control with six per cent BHC dust applied five times over a 10-week period. Brett (1950), however, found five per cent BHC dust unsatisfactory even after repeated applications.

Wene and White (1952) obtained good control by pouring one gallon of 0.2 per cent aldrin, dieldrin or heptachlor into the mound entrance.

Field Studies: Harvester ant control tests with dust and granulated materials were made in conjunction with the fall fire ant control test at Monte Alto. A total of 60 nests was treated with the treatments given in Table 2. Each mound was evenly covered with 100 to 200 grams of insecticide. Records were taken 2 weeks, 6 weeks and 6 months following treatment.

A less extensive test with emulsions was conducted on two lawns at Weslaco. Treatments were one gallon of 2.0 per cent chlordane, 0.25 per cent heptachlor or 0.25 per cent dieldrin poured into the entrance of each nest. Records were taken 2 weeks, 6 weeks and 6 months following treatment.

Results: The data in Table 2 shows that emulsions of 2.0 per cent chlordane, 0.25 per cent heptachlor and 0.25 per cent dieldrin were effective in eradicating harvester ants. No live ants were found around the treated nests two weeks after treatment.

None of the dusts or granulated materials eradicated harvester ants, although surface activity was reduced over a period of two to six weeks after treatment. Slight surface activity was evident around larger nests at six weeks while the smaller nests of ants (3 feet diameter or less) still appeared dead by surface examination although young ants and eggs could be found upon digging into the nest. After 6 months most nests were active as ever.

THE ACROBATIC ANT

Literature reviews The acrobatic ants, *Crematogaster* spp., are known to

reduce the effectiveness of natural enemies of citrus insect pests. The two common species are: *Crematogaster laevinscula clara* Mayr. and *C. arizonensis* Whlr. The former is red and orange, while the latter is entirely black.

The acrobatic ant may be found nesting almost anywhere in the tree. They may be found in bird nests, tree crotches and between leaves over which they build a cover for nests, and in dead areas of limbs or trunk. Wood borer holes provide an excellent nesting site for these ants. They will also build shallow nests around the trunk of the tree at the ground level.

Acrobatic ants are known to feed on the honeydew produced by aphids, soft scales and mealybugs. Dean (1955) reported that where high infestations of soft scale were found acrobatic ants also were numerous. He also noted that where ants were controlled soft scale was not a problem.

Causen (1956) stated that although diaspine scales do not produce honeydew, ants in tending the usually small colonies of aphids, soft scales or mealybugs on the tree incidentally protect the diaspine scales from attack by parasites and predators. DeBach (1950) reporting on his trip through the Texas citrus area stated that the only California red scale infestation which was found with a major proportion of live scale was in association with soft brown scale heavily attended by the red and orange acrobatic ant, *C. laevinscula clara*.

Robert (1946) stated that complete eradication of the acrobatic ant could be obtained with BHC injected into the nest as a 5 per cent dust or as a spray of 4 pounds of 50 per cent wettable BHC to 100 gallons water.

Table 2. Control of harvester ants with various formulations of insecticides.

Treatment[1] *(1 application)*	*Colonies treated*	*Per cent control by surface examination* 2 weeks	6 weeks	6 months
Chlordane				
10% Dust	13	0	0	0
5% Granulated	9	22.2	33.3	0
2.0% Emulsion	3	100.0	100.0	100.0
Heptachlor				
2.5% Dust	6	0	0	0
2.5% Granulated	9	0	11.1	0
0.25% Emulsion	3	100.0	100.0	100.0
Dieldrin				
2.5% Dust	9	11.1	22.2	0
5% Granulated	14	7.1	0	0
0.25% Emulsion	3	100.0	100.0	100.0

[1] Treatment consisted of 100-200 grams of dust or granulated evenly distributed over the nest or 1 gallon of emulsion poured into each nest.

Friend (1947) reported acrobatic ant control by injecting small quantities of plant-safe carbolineum into the cavities or tunnels.

Field studies: Control experiments were conducted in an orange grove near La Feria on October 1, 1955. This grove had been severely damaged by the freeze of 1951, resulting in large dead areas in the limbs and trunk which were heavily infested by the acrobatic ant. Dead areas and suspected ant nests were sprayed with a two-gallon knap-sack sprayer with treatments consisting of 2.0 per cent chlordane, 0.25 per cent dieldrin and 0.25 per cent heptachlor. Each treatment consisted of 6 trees with each treatment being randomized and replicated 3 times. A ring of insecticide was applied around the trunk of each tree to prevent ants from entering the tree from the ground. The treated trees were examined at weekly intervals for two months with a last examination at the end of three months.

Results: The treated areas of the tree remained free of ants for three months with all treatments when a slow invasion of these areas began. Due to the size of the trees a large number of areas were available for nesting sites. Some of these nests were missed during the treatment and as a result invasion of the treated areas occurred from the colonies of ants which continued in the untreated dead areas. Smaller trees in which all dead areas were treated were devoid of ants one week following all treatments and remained so for at least three months.

DISCUSSION

During the tests on fire ants it was found that 75.1 per cent of the fire ant nests in the fall and 55.2 per cent in the spring were found on the south side of the tree. Also, it was found, that if only a part of a nest was treated, ant activity continued in the untreated portion.

Tests indicated that elimination of harvester ants is best achieved through measures directed against the queen and broom chambers. Continuous applications of dusts and granulated materials will kill every worker appearing on the surface and slowly starve the nest; but more often the egg laying persistency of the queen will defeat human determination.

Acrobat ant control is much harder to achieve in trees that have large numbers of dead areas which afford nesting places for the colonies. Pruning and wound treatment would do much to eliminate these nests. The spraying done in the experiment might be duplicated with a paint brush or squirt oil can and be just as effective. Control would be much simpler in trees with little or no dead areas. Ants entering the tree from ground nests could be controlled by banding the trunk with application of sprays or by ringing the trunk with dusts or granulated materials.

SUMMARY

Tests were conducted in the Lower Rio Grande Valley for the control of the fire ant, *Solenopsis geminata*, the harvester ant, *Pogonomyrmex barbatus* var *malefaciens* and the acrobatic ants, *Crematogaster* spp.

Fire ants were controlled with granulated formulations of 2.5 per cent heptachlor, 5.0 per cent dieldrin and 5.0 per cent chlordane and dust formulations of 2.5 per cent heptachlor, 2.5 per cent dieldrin and 10.0 per cent chlordane.

Harvester ants were controlled with one gallon of 2.0 per cent chlordane, 0.25 per cent heptachlor and 0.25 per cent dieldrin emulsion poured into the nest. Harvester ant nests were not eliminated by one application of dust or granulated formulations of heptachlor, dieldrin or chlordane.

Acrobatic ant nests were eliminated from treated areas of the tree for three months with sprays of 2.0 per cent chlordane, 0.25 per cent heptachlor and 0.25 per cent dieldrin. Elimination of the acrobatic ant from the tree was found possible only when all nests and dead areas were treated.

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Observations on Citrus Growing in Spain and Italy During a Trip to Obtain Citrus Seeds[1]

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After attending the 14th International Horticultural Congress in the Netherlands in September, 1955, and sightseeing in England and on the Continent, my wife and I went to Spain and Italy to collect seed of some of the best varieties of citrus grown there. We traveled in a small British-made Ford car which we purchased in California but which was delivered to us in Southampton. Before the trip was over this little car won our affections for its sturdy construction and inexpensive and trouble-free operation over all sorts of roads from the smooth and gentle slopes of the Autobahnen of Germany to the bone-breaking cobble stone roads occasionally encountered in every country we traveled in, but which were especially rough wherever two-wheeled carts were numerous.

The object in collecting seed rather than budwood was twofold: (1) to avoid the delay and the labor involved in growing the material under quarantine and indexing for viruses and (2) to obtain, if possible, nucellar strains of the varieties collected. The chief difficulty was finding enough seed of a few of the almost seedless varieties of oranges.

In Spain we established headquarters at Valencia, the center of the principal citrus region. Through the very kind and generous assistance of Sr. Ramon Boera of Castellon, Sr. Carlos Escriva (Figure 1A) of Valencia, growers in several other localities and members of the staff of the Burjasot experiment station[2], we obtained seeds of about 15 varieties or strains of citrus.

From Spain we went back along the Mediterranean coast through the scenic French and Italian Rivieras, down to Sicily by way of the mountain roads of southern Italy that go through impressive scenery but have been described as being "as tortuous as a bowl of spaghetti," and across the straits of Messina by ferry. We stayed at the resort town of Taormina and drove each day during our stay to the citrus experiment station[3] at Acirele. Dr. Francesco Russo, who had just returned from a year's stay at the Citrus Experiment Station at Riverside, California, assumed all the burden of collecting the seeds for us and conducted us on several tours to different citrus districts. His help was invaluable, for without it we could have obtained seed of only a small part of the 25 varieties or strains secured.

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[1] Presented before the Nov. 22, 1956 meeting of the Rio Grande Valley Horticultural Society.

[2] Estacion Naranjera De Levante, Burjasot (Valencia)

[3] Stazione Sperimentale Di Agrumicoltura E Frutticoltura, Acireale (Catania)

Several of the finest oranges, such as Tarocco and Sanguinello Moscato ,had only shriveled and apparently aborted seeds. Even from these, however, in nearly all cases we obtained a few viable seed that produced several plants of a variety. Included in the collection was seed of the Sicilian sour orange on which the Italian lemons grow to old age with no signs of decline or shellbark. Some of the seeds were sent to the U. S. Department of Agriculture Field Stations at Orlando, Florida, and Weslaco, Texas, and we now have growing in the field at Indio, California, seedlings of 41 varieties or strains from Spain and Italy.

VARIETIES

In both Spain and Italy I had an opportunity to sample in prime condition only early varieties of oranges and tangerines, as we were in Spain in November and in Italy in December, but most of the varieties that I sampled were of excellent quality. The Washington Navel orange, the Algerian (Clementine) tangerine and the common, or Mediterranean, mandarin are grown extensively in Spain. This "Mandarine Comun", which is also the most widely grown tangerine in Italy, has an orange-yellow skin, is somewhat larger than our Dancy or Algerian, and has 15 to 25 large seeds. From the fruits I sampled, it seemed that the Sicilian strain of this mandarin has fewer seeds than the Spanish strain. The varieties in Spain that seemed to me to be of greatest promise for the desert areas of the Southwest are the Salustiana, an almost seedless round orange (we found only 24 seed in about 500 fruit) of good quality that ripens as early as the Washington Navel, and an almost seedless strain of Clementine tangerine, that in spite of its seedlessness is said to set good crops in Spain. The Cadenera, a midseason orange of high quality, may also prove to be valuable if the nucellar seedlings produce fruit of larger size than the old-line Cadenera, which has proved to be undesirably small for this country.

Among the varieties of orange sampled in Italy two of the best were Tarocco and Sanguinello (Figure 1 B, C) both classed as "bloods". The variety Moro was spectacular for the dark-red flesh and juice, but its quality was poor. It may, however, prove to be invaluable to the breeder in developing blood varieties for this country. The Tarocco was superb. As grown in Sicily, it is large, peels fairly easily, and has firm but tender and melting flesh with no noticeable rag and with very pleasing and distinctive flavor. Early in the season when first mature it shows almost no red color. The old-line Tarocco as grown in this country is a weak grower and a shy bearer and the fruit is small. Perhaps these faults will be less pronounced in a nucellar strain. The Sanguinello is one of the principal early varieties in the Lentini, Catania and Paterno districts of Sicily and is a heavy bearer. The fruit is nearly seedless and of high quality. We obtained seeds of 4 distinct strains of this variety. The Ovale, which is the principal non-blood variety in Sicily, is late ripening and was too immature to sample in December. It is less popular, however, than the blood varieties.

We visited the district along the coast south of Reggio Calabria on

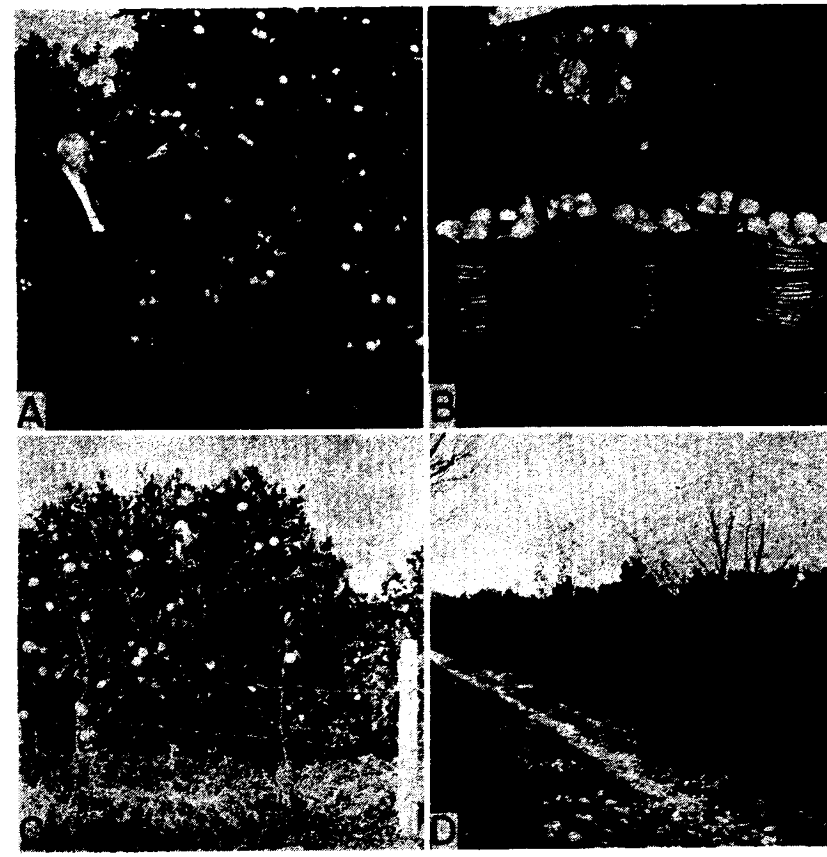

Figure 1. (A) Sr. Carlos Escriva beside a Washington Navel orange tree in his orchard near Valencia. (B) Baskets of Tarocco and Sanguinello oranges grown at Acireale experiment station. (C) and (D) Sanguinello orange planting in Paterno district, showing small, low-headed, closely spaced trees. In (D) the deciduous trees along the border are pears.

the "toe" of the Italian mainland where most of the Bergamot oranges are grown. These fruits, which are grown for the oil contained in the peel, look like large, nearly round lemons. They have a distinctive nipple and yellowish-green skin. The peel is thick, and the pulp non-edible. When we saw them in late December they were being harvested from the rather small open trees by pickers who stood either on the ground or on the scaffold limbs and tossed the fruit into baskets.

ROOTSTOCK AND TREE SPACING

In both Spain and Italy the sour orange, because of its resistance to foot rot, is practically the only rootstock used regardless of the scion variety. At the citrus station at Burjasot, even the satsuma oranges were flourishing on sour orange stock. This, of course, indicates that not even their satsumas are carrying tristeza virus. Most of the soils on which I saw citrus in both Spain and Italy were loams or clay loams and, except on the terraced mountain sides of the Sorrento peninsula, all citrus plantings were irrigated. This in part explains the necessity for the universal use of sour orange stocks.

In general the trees are closely spaced (Figure 1 C. D). In Spain the spacing of oranges and tangerines varied from about 8 or 10 feet to possibly 22 feet, but most of them were about 15 to 18 feet apart. In Italy spacing varied with the district and the variety. In the Paterno and Lentini districts in Sicily, where oranges and tangerines are the princpal crops, the spacing was about 10 to 15 feet; in the Fondi district, not far south of Rome, oranges are planted 4 or 5 feet apart in rows about 10 feet apart. The spacing of lemons in the Acireale area varies greatly. In the old plantings lemons were often spaced 10 to 15 feet apart, and in the recent ones sometimes as much as 18 to 20 feet apart. There is, however, much irregularity in spacing because after the ravages of mal secco, a fungus disease, the replanting often is done with several trees to fill a gap left by the death of the old tree. Presumably these will be thinned out as they get older and begin to crowd.

HEADING, PRUNING AND TRAINING

In both Spain and Italy, oranges and tangerines in nearly all districts that we visited were usually headed about as low as possible without crowding the scaffold branches too closely together. Only in the Fondi district of Italy did we see oranges headed high. Here, as in the lemon plantings of Sicily, sour orange stocks grown for 2 years or longer in the nursery row are budded at a height of 2½ to 3 or even 4 feet. This practice seems to cause dwarfing and heavy fruiting of the oranges and tangerines and it also serves to get the tops well above the wet clay of the Fondi district. It is possible that the extremely high heading of oranges is done in part to protect the fruit from fungus infection and also to enable the workers to move about under the branches of the very closely spaced trees. Lemons in the Acireale district are budded at 2 to 3 feet and as the trees grow older the heads may be formed still higher by pruning off the lower branches (Figure 2A). This extremely high heading is practiced to reduce the chances of infection by the fungus that causes mal secco. In the Murcia district of Spain lemons are headed as low as they are in the United States, probably because the climate is so arid that the trees are relatively free of disease.

Pruning and training of trees are very carefully and skillfully done in both Spain and Italy. In most districts training into a branching system designed for ease of harvesting and other operations is begun early, and bearing trees are pruned fairly heavily so that the tops are kept low and small, but the pruning is so skillful that the cuts are not apparent without a close examination of the trees. No dead twigs or weak branches are seen and the inside branches are not shaded out. In spite of the close

planting, trees are pruned so as to avoid serious crowding and yet are kept thinned out so that pickers may move about in them easily. The trees in most orchards were heavily loaded with fruit of good size and color. I was told in Sicily that the lemon trees are pruned every 2 years. There the tops were kept open, growth was not excessive, and there were no long branches bending down to form a skirt as is usual in this country. The lemon trees were not heavily loaded in December and seemed not to bear as heavily as in California, but this appearance of light bearing may have resulted from some of the crop's having already been harvested. Apparently, except for lemons in Italy, which are not only budded very high, but as they grow older, are often pruned so as to get the bearing surface 5 or 6 feet above ground, picking is done from the ground or by standing on the scaffold limbs.

HARVESTING

In all of the harvesting we observed in Spain and Italy the fruit was picked into small baskets that would hold about a half-bushel. These baskets were apparently hand-woven in great numbers on the farms where they were used, largely from the giant reed that is widely used for wind-breaks in the desert areas of Arizona and California. In picking, the baskets were placed in a circle around the tree, or were carried into the interior of the tree and supported on branches. The picker standing on the ground or on the main limbs, rapidly snapped the fruits off and dropped them into the baskets. The mandarin oranges were sometimes picked by breaking off long stems attached to the fruit. The picking baskets were carried to the nearest driveway where the oranges were either emptied into field boxes of the same type used in this country or were poured into great heaps or windrows from which they were later placed in boxes and hauled to the packing house on trucks. Because of the close spacing of trees, trucks could not, in most orchards, be driven between rows, and besides, trucks were so expensive in Spain that their use was largely confined to fairly long distance hauling on the highways.

CULTIVATION AND INTERCROPPING

Cultivation is done with horse and plow (Figure 2B) in young or open plantings in Spain, but in the terraced orchards and the very closely spaced plantings in Spain and Italy cultivation is done with a heavy hoe that has a large blade with a spade. This tool is similar, we were told, to the one the old Romans used for the same purpose. The modern Italian farmer, who may operate only 2 or 3 acres of lemons and possibly some inter-crop, uses this hoe with amazing skill and endurance and keeps his farm in excellent condition. He has no plow-sole problem and apparently no trouble in growing replants.

In Italy and especially in Spain the acreage in citrus has been expanding rapidly. We saw many young non-bearing orchards in both countries, and, in general, even the bearing trees were relatively young and vigorous. Spain seems to have more land suitable for expansion than

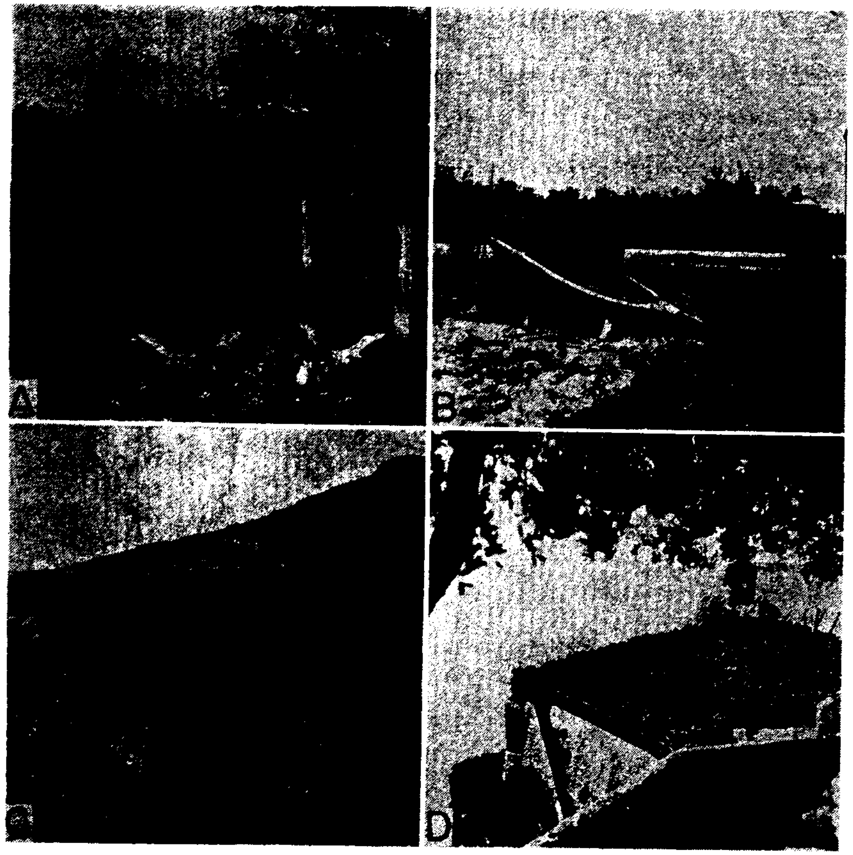

Figure 2. (A) Lemon orchard in Acireale district, showing old trees with high heads, the stump of a tree that had been killed by mal secco and just removed and young replants. (B) A type of plow commonly seen in Spain. (C) Young lemon planting in Murcia district with dry hills similar to those of the southwestern United States in background. (D) Terrace on Sorrento peninsula; lemons planted under a framework of poles and covered by brush mats for frost protection.

Italy. In the Murcia area, for example, where there are considerable areas suitable for lemons, there are many extensive young lemon plantings (Figure 2 C). In Italy, however, many irrigated vineyards were being planted to citrus. The citrus trees were planted among the vines, which were cropped until crowded out by the citrus. In both countries there were also numerous large nurseries full of young trees. Everywhere young orchards were intercropped with vegetables or other low-growing plants as long as the soil was not too severely shaded.

TERRACED ORCHARDS

In order to utilize warm sites especially for lemons but often also

for oranges, elaborate terraces with hand-laid rock retaining walls and surface irrigation conduits running down hill from terrace to terrace have been constructed on many acres in both Spain and Italy. In Spain near Valencia we visited a hill-side orchard in which terraces of about 10 acres in extent were being constructed for planting to lemons. The retaining walls of the terraces were 5 or 6 feet high and constructed of carefully fitted quarried stone. The enormous amount of soil needed to fill these terraces was being hauled by two-wheeled carts. The carts were loaded by raking soil with short-handled hoes into baskets, which in turn were dumped into the carts. This site had been selected because it was nearly frost-free, not because of extreme scarcity of land.

The most spectacular terraced citrus orchards seen were the lemon plantings in Italy on the Sorrento peninsula (Figure 2 D). In some places these terraces, often just wide enough for a single row of trees, extend like great stairsteps from the sea far up the mountain side. To protect the trees from frost the terraces are covered with a permanent frame-work of slender, second-growth chestnut poles, securely lashed together with wire and covered each winter with reed or brush mats. The frame-work is high enough to permit workmen to walk erect beneath and sturdy enough so that they can walk on top. The lemon branches that grow above the frame-work are either pruned off or tied down to the frame-work with willow withes taken from basket willows that are often grown near the lemon trees. These operations were being performed about mid-December. In the vicinity of Amalfi and Sorrento there were many acres of these covered terraces with little patches of olives, grapes, or other plants tucked in wherever there was any space between the citrus terraces. An apalling amount of labor must have gone into the construction of these terraces. We saw soil being transferred by bucket and windlass from a truck parked on the highway to little terraces that were being constructed far below. On some of these, only a single tree could be planted. One is forced to admire the sturdy people who make a living on these mountain sides and who, in the process, have created one of the beauty spots of the world.

DISEASES

The numerous and large plantings of the Washington Navel orange in Spain were seriously affected by psorosis, which had evidently been introduced with the budwood. Topworking of extensive blocks to change to another variety is a common practice in Spain and this has doubtless contributed to the spread of viruses. Incidentally, topworking is done with a large patch of bark containing two or three buds. This is simply tied in place with raffia with no further protection against water loss. The Spanish consider this method to be superior to the ordinary shield budding. We also observed in Spain some cases of what appeared to be foot rot or gummosis. The soil had been carefully excavated from around the main roots, leaving them in a basin free of soil for a foot or so from the trunk, and the basin was kept dry to avoid further growth of the fungus causing the trouble.

In Italy some foot rot was also evident, but to my surprise I saw no trees that were so obviously affected by psorosis that I could recognize it.

In the lemon plantings in the Acireale area it was clearly apparent why one of the major projects at the Acireale experiment station is the breeding of lemons for resistance to mal secco. This disease is caused by a fungus that invades the wood of branches, trunk and roots and quickly kills branches or entire trees of susceptible varieties of lemon. All the old lemon plantings in the Acireale area contained trees that had been heavily pruned to remove the diseased parts and in many plantings a large proportion of the trees were replacements varying greatly in age (Figure 2 A). The Monachello, a resistant variety of lemon, is being used now to replace some of the more susceptible varieties. It is ,however, considered to be of poorer quality than the Femminello, which was formerly the principal variety in the Acireale district.

In the Lentini and Paterno districts where the soils are derived from limestone, we saw several orange plantings that were showing pronounced iron chlorosis, but other than this I saw little evidence of minor-element deficiencies. In general, the citrus in both Spain and Italy had good color of foliage, was vigorous and appeared to be healthy. The oranges for the most part carried heavy crops of medium-sized fruit of good color. Except in areas where mal secco occurs the lemons also were healthy and vigorous.

GENERAL COMMENTS

The citrus industries of Spain and Italy have prospered greatly since World War II. Several factors, I think, account for this. Some of the old plantings were eliminated during the Civil War in Spain and possibly also during World War II in Italy, and accompanying the new planting there has been a rapidly expanding market for citrus in Europe. The soils in the citrus-growing districts seemed to be fertile except for deficiency of nitrogen, which has been supplied largely from inorganic salts; and apparently the quality of the water available for irrigation is good, as I saw no evidence of injurious accumulations of salt. In both Spain and Italy there is an abundant supply of intelligent, skillful and amazingly energetic labor available at low cost. In both countries citrus has been grown for a long time and many excellent varieties admirably suited to the climate have originated from seedlings. This may have resulted in a lower incidence of virus diseases than is true in citrus-growing countries that have imported many old varieties from the Orient. Probably of first importance is the mild Mediterranean climate that seems to be exceptionally well suited to the production of oranges, tangerines and lemons.

Trends in Citrus Fruit Production in the Lower Rio Grande Valley

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Since the early settlement of the Valley much interest has been shown in the growing of citrus and in more recent years in the production of red-fleshed grapefruit. The citrus industry had its beginning in about 1909. New commercial plantings and a large-scale development of the industry brought steadily increasing production until a peak was reached in 1945-46. This peak was followed by a low in 1951-52 following the two disastrous freezes which came in January 1949 and 1951.

This study reports the trends of citrus fruit production during a 10-year period, 1946-47 to 1955-56. This period includes two full seasons before the freeze of 1949 and five seasons following the freeze of 1951. Production, both fresh and processed or canned fruit, is reported.

As shown in Table 1 and in Figure 1 grapefruit and oranges are the principal citrus fruits grown. Other fruits such as limes and lemons are grown, but the shipments have been too small to warrant compilation. Limes and lemons are much less freeze tolerant than grapefruit and oranges, which accounts in part for the lack of interest in their production. Throughout this 10-year period grapefruit has been shipped in much larger quantities than oranges, however; the proportion of grapefruit production has decreased while that of oranges has increased. During the first 5-year period, 1946-47 to 1950-51, of the total fresh shipments 71.7 per cent was grapefruit and 28.2 per cent was oranges. In the second 5-year period, 1951-52 to 1955-56, of the total shipped 58.5 per cent was grapefruit and 41.5 per cent oranges. This shift in production has been more marked since the 1951 freeze, and is probably due primarily to the better survival of orange trees exposed to freezes as compared to grapefruit and to the higher tolerance of orange trees to salt injury. A high proportion of new plantings are of red grapefruit suggesting that the trend will be reversed as the new grapefruit plantings come into bearing.

The strong impact of the disastrous freezes of 1949 and 1951 on the citrus industry is shown in Tables 1 and 2 as illustrated by the high of 37,862 cars in 1946-47 followed by a low of 104 cars five years later.

The industry is attempting a recovery from the severe set-back which resulted from these two freezes and subsequent droughts in 1955 and 1956. The production has been increasing each year, but the expected heavy increase did not materialize in 1955-56. This was due for the most part to a severe blossom shed during the last few days in March 1955 when a strong cold desiccating north wind occurred. The temperature dropped to near the freezing point and the combination of conditions resulted in severe and wide-spread blossom drop. Production figures for the current year are not available at this time, but estimates are for a larger crop than last year despite the high percentage of small sizes this season.

As shown in Table 2 and in Figure 2 the principal canned citrus fruit products are grapefruit, orange and grapefruit blend, and orange juice. Prior to 1950-51 a moderate amount of grapefruit sections were

Table 1. Shipments of Fresh Citrus Fruit.[1]

Years	*Grapefruit*	*Oranges*	*Tangerines*	*Total*
	Number of cars[2]			
1946-47	28,250	9,586	26	37,862
1947-48	24,071	9,122	29	33,222
1948-49	11,795	5,673	8	17,476
1949-50	7,398	2,868	19	10,285
1950-51	5,425	2,983	31	8,439
1951-52	62	42	0	104
1952-53	188	103	2	293
1953-54	1,162	846	2	2,010
1954-55	2,454	1,546	5	4,005
1955-56	2,302	1,827	7	4,136

[1] Source of data: Winfrey, R. E.—See literature cited.

[2] Conversion factor of 400 boxes per car used prior to 1948-49 and subsequently 500 boxes per car. Mixed cars computed on basis of 60 per cent grapefruit and 40 per cent oranges. The number of cars represents shipments by rail, boat, and truck for all seasons except 1951-52 and 1952-53 when only rail and boat shipments figures were obtained.

Table 2. Shipments of Canned Citrus Fruit Products.[3]

Years	*Grapefruit juice*	*Orange juice*	*Grapefruit and Orange juice blend*	*Grapefruit sections*	*Total*
		Number of cases[4]			
1946-47	8,239,813	102,265	340,437	490,310	9,172,825
1947-48	8,981,267	165,096	298,883	241,800	9,687,046
1948-49	4,944,258	296,067	228,890	189,421	5,658,636
1949-50	2,679,589	144,528	44,672	----	2,868,789
1950-51	4,550,714	869,945	369,339	21,781	5,811,779
1951-52[5]	50,000	----	----	----	50,000
1952-53[5]	100,000	----	----	----	100,000
1953-54	268,328	12,328	656	----	281,312
1954-55	443,951	66,446	11,633	----	522,030
1955-56	334,954	49,260	8,657	----	392,871

[3] Source of data: Texas Canners Report—See literature cited.

[4] Computed on basis of 24—No. 2 cans per case.

[5] Report for 1951-52 and 1952-53 made no breakdown of citrus products; however, nearly all was grapefruit juice, so all is shown as that product.

FIGURE 1.-PRODUCTION OF FRESH CITRUS FRUIT

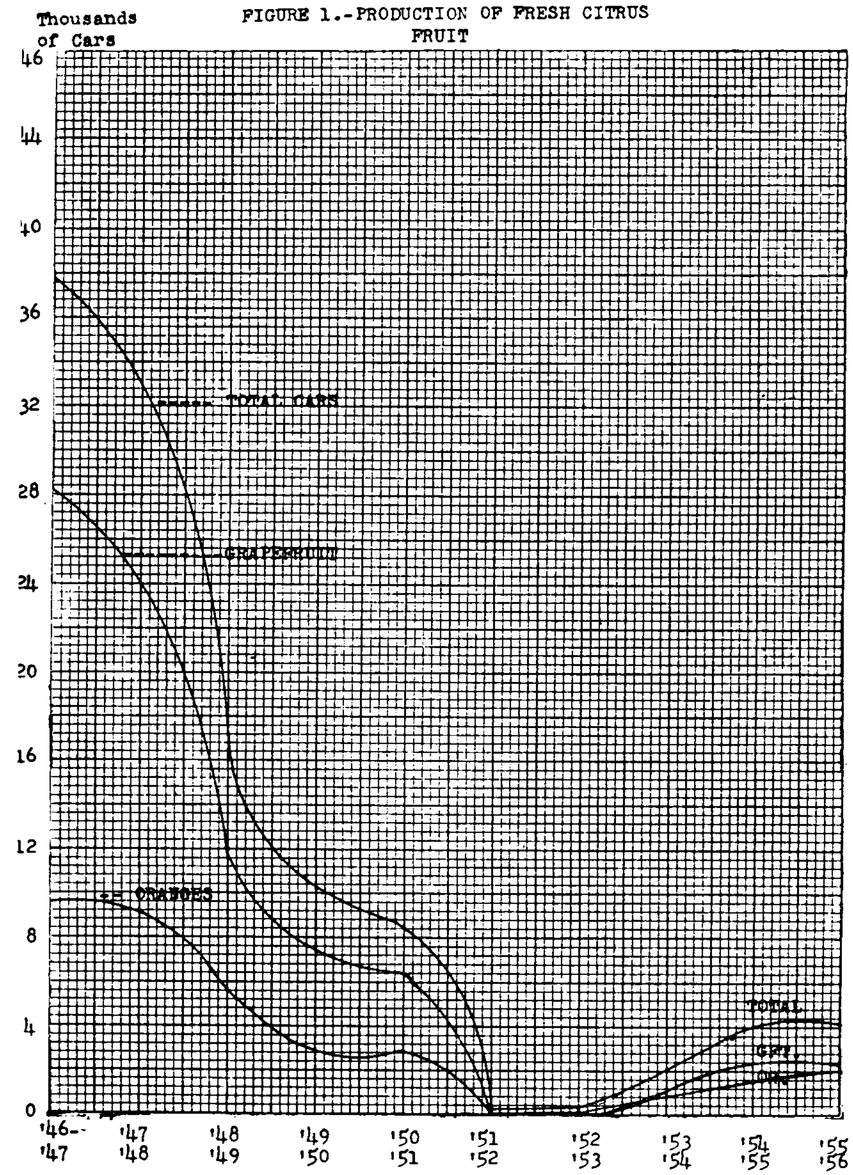
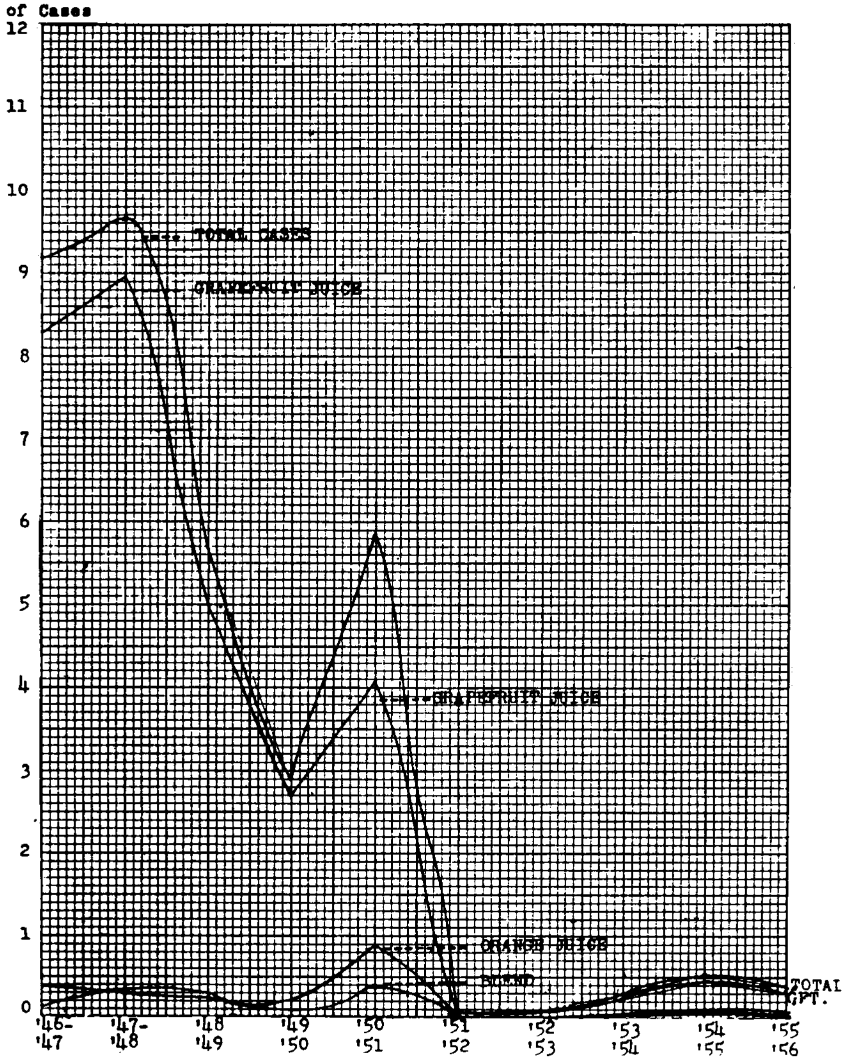


FIGURE 2.-PRODUCTION OF CANNED CITRUS FRUIT



canned, but since that time there is no record of any having been canned. The freeze caused a sharp drop in the pack of the canned products, although there was some increase on the year of the freeze, since large quantities of the fruit which could not be shipped fresh was canned.

The production of canned citrus juices shows an upward trend despite a small setback in 1955-56. While no official figures are available as to the total pack this season, estimates are that it will reach 1,000,000 cases which is more than double the size pack of the past season. This increased pack is due to the normal culling from a larger fruit crop, and to the increased percentage of fruit being sent to the processing plants due to the large volume of small sizes resulting from the lack of sufficient irrigation water for the groves.

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AVOCADO SECTION

EVERETT BALLARD—*Section Chairman*

Salt-Tolerance and Cold-Hardiness Tests On Avocado Trees.

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Salt and cold injury are the major problems in the commercial production of avocados in the Rio Grande Valley of Texas. Both kinds of injury are characterized by leaf burning, twig dieback, and in extreme cases by death of the tree. Salt injury is associated with high soil salinity and a high chloride content of the leaves, just as in citrus (Cooper and Gorton, 1950), while cold injury results from freezing temperatures. Frequently after freezes a tree may show both salt-excess and cold-injury symptoms, and these symptoms may be visually indistinguishable. However, analysis of the tissue for chlorides will distinguish them.

Observations in citrus and avocado orchards on saline soils in the Rio Grande Valley showed that all varieties of avocados under cultivation, including Waldin (West Indian race), Itzamna (Guatemalan race), Lula (West Indian-Guatemalan hybrid), Fuerte (Guatemalan-Mexican hybrid) and Jalna (Mexican race), showed considerably more leaf burning than adjacent trees of grapefruit and orange (Cooper and Gorton, 1950). There was, however, a wide range in extent of salt injury of the various avocado varieties on the same rootstock; Waldin, Lula, and Itzamna showed less salt injury than the Fuerte and Jalna.

Most of the information on cold hardiness in avocados in the Rio Grande Valley is based on observations of cold injury subsequent to the freezes of 1949 and 1951 (Cooper et al, 1949; Cintron et al, 1952). Most varieties and selections of the Mexican race showed much less cold injury than varieties of other races and their hybrids, including such varieties as Fuerte, Lula, Itzamna and Waldin. In general, trees of West Indian, Guatemalan, and West Indian-Guatemalan hybrid varieties showed severe wood injury, some being killed outright, while trees of the Mexican race showed only leaf and twig injury. The selections of Mexican hybrids showed damage to the wood, ranging from none to severe.

Since soil salinity under field conditions is generally variable and uncontrolled, field observations on the relative tolerance of various scion varieties have their limitations. Likewise, testing cold hardiness of avocados by field survival is basically a waiting process since winters severe enough to separate the partially hardy varieties from the fully hardy ones have not occurred since 1951. The objectives of the present studies were (1) to determine whether field-survival observations for cold hardiness and salt tolerance can be replaced by artificial freezing and salt-tolerance tests under controlled conditions and (2) to classify varieties and selections of avocados as to cold and salt tolerances.

METHODS

The procedures used for the salt-tolerance tests were those described elsewhere for citrus (Cooper et al, 1951). The salt solutions used to irrigate the salinized plots consisted of a 50-50 mixture of NaCl and $CaCl_2$ to give a concentration of 3000 ppm of total salts, 88 per cent of which was chloride ion. While approximately 50 per cent of the total cations in this solution were sodium, enough calcium was present in the mixture to prevent puddling the soil.

The avocado varieties or selections tested included Lula, Castro, Pancho, and Arsola selections 29-9, 1-8, and 5-6. The Pancho and Castro are selections of the Mexican race, while the Arsola selections are considered to be Mexican-West Indian hybrids. One tree of each variety was included in each of 4 plots. The trees in each plot were planted in a randomized manner 3 feet apart in 2 rows 3 feet apart.

Grafted trees, with a trunk circumference of approximately 25 mm., were planted on March 15, 1955. The trees were irrigated with 3 inches of salt solution or of river water at approximately 2-week intervals. River water was used from March 15 until June 20, 1955; the salt solution from June 20 until August 9, 1955; river water from August 9, 1955, to May 3, 1956; salt solution from May 3 to August 10, 1956; and river water thereafter.

The tree-freezing unit and method of operation are the same as those described elsewhere for citrus (Cooper et al, 1954). The numbers of trees and the selections or varieties tested are as follows: Two of Lulu, 3 of Castro, 1 of Pancho, 4 of Arsola 1-18. The trees were grafted on West Indian rootstock and were of the same age and size as the trees tested for salt tolerance. The freezing tests were conducted during December 1956 and January 1957.

RESULTS AND DISCUSSION

The effects of the salt and freezing treatments on the trees of the various kinds of avocados are described in tables 1 and 2 and figures 1 and 2. A tentative classification of 6 kinds of avocado as to salt tolerance and of 4 kinds as to cold hardiness is given in table 3. Additional work is needed to give a more accurate and comprehensive picture of the salt tolerance and cold hardiness of these kinds of avocado. The variety and selections were given numerical ratings for salt tolerance and cold hardiness. The values increase with increase in salt tolerance and cold hardiness A value of 1 was given to completely killed trees (killed by 3 hours of 23°F in case of cold hardiness), and a value of 5 to those showing no injury under the same conditions of freezing or salt treatment. Intermediate values reflect intermediate degrees of injury. Salt-tolerance and cold-hardiness ratings for grapefruit on sour orange (Cooper et al, 1951 and 1954) are also given for comparison with those of the avocado.

Figure 1. Complete defoliation and twig dieback on trees of the Pancho selection on West Indian rootstock grown in plots irrigated with salt solution containing 3000 ppm. of a mixture of NA Cl and CA Cl_2. Picture taken September 10, 1956.

Table 1. Salt injury, chloride content of leaves and increase in trunk circumference of 6 kinds of avocados grown in artificially salinized plots.[a]

Selection or variety and date of observation	*Extent of salt injury*	*Con. of chloride in leaves (% dry weight)*	*Circumference of trunk (mm.)*
Arsola 29-9			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.66	–
July 26, 1956	Slight defoliation	.81	–
September 10, 1956	Complete defoliation	–	76
December 10, 1956	3 out of 4 dead	–	69
Pancho			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.40	–
July 25, 1956	Slight defoliation	.42	–
September 10, 1956	Complete defoliation; twig die-back	–	76
December 10, 1956	3 out of 4 dead	–	73
Castro			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.38	–
July 26, 1956	Slight defoliation	.54	–
September 10, 1956	Complete defoliation, twig die-back	–	68
December 10, 1956	All dead	–	67
Arsola 5-6			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.43	–
July 26, 1956	Complete defoliation	.78	–
September 10, 1956	Severe twig dieback	–	74
December 10, 1956	3 out of 4 dead	–	68
Lula			
June 20, 1955	None	–	30
August 9, 1955	Moderate leaf burn	.29	–
July 26, 1956	Moderate leaf burn	.60	–
September 10, 1956	Severe leaf-burn; Slight defoliation	–	86
December 10, 1956	All old leaves defoliated	–	97
Arsola 1-18			
June 20, 1955	None	–	30
August 9, 1955	Moderate leaf-burn	.53	–
July 26, 1956	Moderate leaf-burn	.70	–
September 10, 1956	Severe leaf-burn; slight defoliation	–	97
December 10, 1956	All old leaves defoliated	–	97

[a] Salt treatment applied June 20 to August 9, 1955, and from May 3 to August 10, 1956. River water applied at other times.

Figure 2. Severe leaf burn on old leaves, but no injury on new leaves on trees of the Lula variety on West Indian rootstock grown in plots irrigated with salt solution containing 3000 ppm. of a mixture of NA Cl and Ca Cl_2. Picture taken at the same time as that of the Pancho selection shown in Figure 1.

Table 2. Condition of trees at time of freezing, freezing temperature and extent of freeze injury of 2-year-old Avocado trees of varieties or selections, grown in the field at Rio Farms, Inc., Monte Alto, Texas, 1956 and 1957.

Selection or Variety	*Date of freezing treatment*	*Tree condition before freezing treatment*	*Freezing temp.*[a] *(° F.)*	*Extent of freezing injury*[b]
Pancho	December 31	Buds dormant	23	A few leaves and twigs in top of tree killed
Castro	January 2	Full bloom	23	Bloom and a few leaves and terminal twigs killed
Castro	January 29	Full bloom	26	No injury to bloom
Castro	January 30	New flush growth	26	No injury to new flush
Lula	January 3	New flush growth	24	Entire top of tree killed
Lula	January 29	New flush growth	26	No apparent injury
Arsola 1-18	December 31	Buds just breaking	23	All leaves and all wood ½" in diameter killed
Arsola 1-18	January 2	Buds just breaking	22	Upper half of top of tree killed
Arsola 1-18	January 3	Buds just breaking	23	All leaves and all wood ¼" in diameter killed
Arsola 1-18	January 28	Buds just breaking	23	All leaves and all wood ¼" in diameter killed

[a] All trees were held at the indicated temperature three hours.
[b] Estimated 2 weeks after freezing treatment.

Table 3. Classification of avocados as to salt tolerance and cold hardiness.

Selection or Variety[a]	*Race*	*Units of*[b] *salt tolerance*	*Units of*[b] *cold hardiness*
Castro	Mexican	1	4
Pancho	Mexican	1	4
Arsola 29-9	Mexican-West Indian	1	d
Arsola 1-18	Mexican-West Indian	3	3
Arsola 5-6	Mexican-West Indian	1	d
Lula	Guatemalan-West Indian	3	1
Grapefruit on sour orange[c]		5	4

[a] All were propagated on West Indian rootstock.
[b] Values increase with tolerance and hardiness.
[c] Values based on other work (Cooper et al, 1952) included here for comparison only.
[d] No determination.

The salt-tolerance and cold-hardiness ratings derived from tests under controlled conditions agree with those obtained by field-survival observations, and such tests are recommended for screening varieties and selections of avocados for salt-tolerance and cold-hardiness. The results of the freezing tests at 23°F, however, do not indicate the actual extent of freezing injury to be expected from a natural freeze at 23°F. The rate of cooling, wind velocity, relative humidity and possibly other factors affecting freezing injury during the artificial freezing period are not necessarily comparable with conditions during a natural freeze in the Rio Grande Valley. The test conditions, however artificial, were identical for the various kinds of avocado and comparisons of cold hardiness are valid.

The ratings of these kinds of avocado as to salt tolerance and cold hardiness illustrate the basic problem in selecting suitable avocado varieties for the Rio Grande Valley. A suitable selection should have both salt tolerance and cold hardiness. Yet one of the selections with the greatest salt tolerance, the Lulu, showed the least cold hardiness. The Mexican selections, one the other hand, showed poor salt tolerance but good cold hardiness. The selection which showed the highest combined ratings of cold hardiness and salt tolerance was Arsola 1-18, which showed a high value for salt tolerance and an intermediate value for cold hardiness. Field observations on the Arsola planting of Mexican-West Indian hybrid seedlings at Llera, Tamps., Mexico, indicate a range in cold hardiness for these trees (Cintron et al, 1952). More of these selections should be tested for both cold-hardiness and salt-tolerance. Among these selections may be one that is superior to Arsola 1-18.

The relatively high rating given the Arsola 29-9 selection in the classification of subtropical fruit plants for salt-tolerance by Cooper et al (1952) is not consistent with the poor performance of this selection in the present series of tests. The earlier rating was based on a comparison of the Fuerte variety and the Arsola 29-9 selection. Presumably Arsola 29-9 has salt tolerance superior to that of Fuerte variety but not equal to that of the Lula variety.

SUMMARY

The Lula variety, 2 selections of the Mexican race, and 3 selections of Mexican-West Indian hybrids were tested for salt tolerance and cold hardiness by artificial tests under controlled conditions. The salt-tolerance and cold-hardiness ratings obtained agree with those obtained by field-survival observations. The Lula variety showed a high salt tolerance rating but a low cold hardiness rating. The Mexican selections, on the other hand, showed a low salt tolerance rating and a high cold hardiness rating. A Mexican-West Indian hybrid, Arsola 1-18, had the best combined salt-tolerance-cold-hardiness ratings.

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Some Notes on the Susceptibility of Avocados in Mexico to Attack by the Mexican Fruit Fly

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The susceptibility of avocados to attack by the Mexican fruit fly (*Anastrepha ludens* Loew) has become increasingly important. This is due to the recent trapping of flies near the California-Mexican border, the increasing interest in the varieties suitable for growing in the lower Rio Grande Valley of Texas, and the difficulties involved because of lack of a safe, effective treatment to permit shipment under quarantine.

In May 1956 a study of infestation in avocados by this fly under both field and laboratory conditions was undertaken. Thus far 15 states in Mexico have been covered or visited in part in a preliminary survey to locate plantings suitable for this work (Figure 1). The average annual rainfall and average number of days with frost in Mexico, based on the period 1921 to 1930, are shown in Figures 2 and 3, respectively.

Information on the more important areas covered may be of interest to those planning visits into Mexico in search of new avocado varieties.

Areas of Major Interest for Avocado Selection

Queretaro-Guanajuato Area.—In view of the necessity for the selection of cold-resistant varieties suitable for the Rio Grande Valley, the plantings in and around the towns of Comonfort and Rinconcillo in the state of Guanajuato, and La Canada, Taliman, Queretaro, and San Juan del Rio in the state of Queretaro appear promising. Here there are many groves planted from selected seed apparently of Mexican, Guatemalan, and West Indian races and their hybrids growing at altitudes between 6,000 and 7,000 feet. The annual rainfall is between 15 and 30 inches (400 and 800 mm) (Figure 2), and in normal seasons the fruiting time is between May and August. For several years this area has had heavy freezes that damaged 50 to 70 per cent of the avocado trees (Figure 3). Some, however, came through with no apparent ill effects.

A great deal of trouble with insect pests is encountered here and some trees have been dying back from the cinnamon fungus (*Phytophthora cinnamomi*). These factors should make this area particularly suitable for selection of resistant varieties.

Northern Veracruz and Puebla Area.—A second area of interest is in the northern parts of the states of Veracruz and Puebla, including the towns of Tezuitlan, Jacopoaxtla and the area around it, and Jalacingo. The altitude is for the most part above 6,000 feet and a heavy annual rainfall between 30 and 60 inches (800 and 1500 mm) (Figure 2) with freezing temperatures almost every year (Figure 3). Deciduous fruits are also grown with avocados planted as border rows in some orchards. However, most avocados are growing as yard plantings or in small groves.

Figure 1. Map of Mexico showing area covered in study of susceptibility of avocados to attack by the Mexican fruit fly.

Figure 2. Annual rainfall in Mexico, 1921 to 1930.

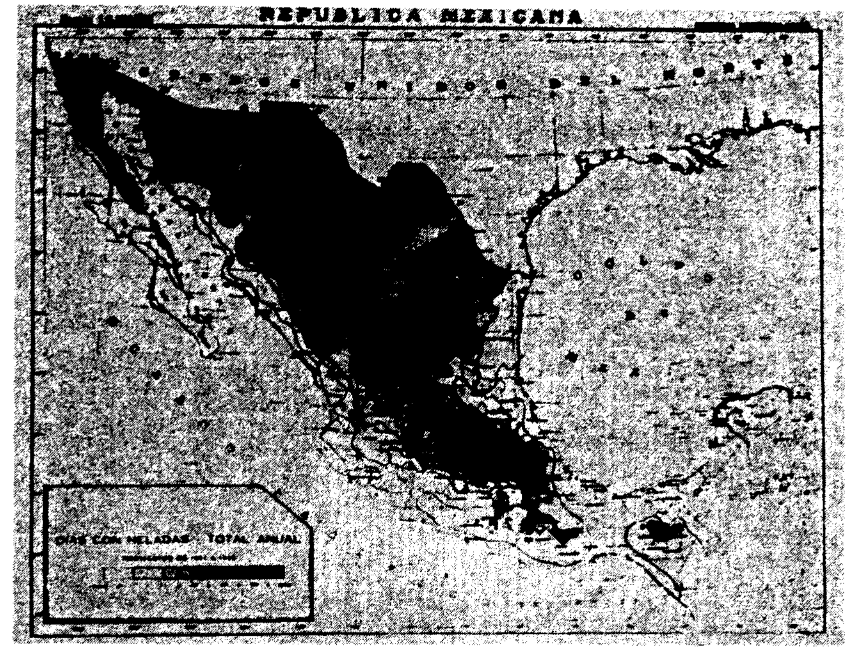

Figure 3. Average days with frost in Mexico 1921 to 1930.

Most of the pests found in the Queretaro-Guanajuato area are also found here except for the cinnamon fungus. Most of the trees are of the Mexican race with a possibility of Mexican-West Indian hybrids. The main fruiting season begins in May and ends in July.

State of Mexico.—In the state of Mexico at altitudes up to 8,000 feet several plantings of avocados have been reported that have not been visited. Most of this state has freezing temperatures every year.

San Cristobal de las Casas and Vicinity.—The area north of San Cristobal de las Casas in the state of Chiapas is between 6.000 and 8,000 feet in altitude and has some of the heaviest rainfall in Mexico, ranging between 70 and 150 inches (1800 and 3800 mm) per year (Figure 2). Once every three to five years there are freezing temperatures (Figure 3). The Guatemalan-type avocados growing in this area show considerable cold tolerance. This is also true of the area northwest of Tapachula along the Mexican-Guatemalan border. Here there are several extinct volcanoes reaching heights of 10,000 to 13,000 feet. Avocados are growing on their slopes, but can be reached only by horse or on foot through some very rough country.

Though Chiapas has a very heavy annual rainfall, no cinnamon fungus was found. In fact, few avocado pests seem to thrive in this part of Mexico.

San Angel de Ziracuaratiro.—This locality in the state of Michoacan has some very old avocado trees. Some trees are claimed by the natives to be one hundred to two hundred years old. Some are so large that rope systems have been installed to permit pickers to reach the fruit. Most, if not all, of these trees are pure Mexican and produce excellent fruit. No freezes are reported for this area, which lies about 30 miles east of Uruapan. The fruiting season is between April and July.

Preliminary Infestation Results

From time to time avocados infested with the Mexican fruit fly have been intercepted at the United States-Mexican border. They had also been found in the market and collected in the field prior to this study. However, in May and June 1955, J. M. Ramirez of the USDA Plant Pest Control Branch, accompanied by F. Islas and E. Jimenez of the Mexican Department of Agriculture, found no infestation in 4,774 avocados dissected in the field.

In the survey made in 1956 samples of avocados were returned to the laboratory where the fruit was held over moist sand to permit any larvae present to mature, leave the fruit, and pupate. This system gives a better indication of infestation than field dissection. By this method 165 *Anastrepha* flies were recovered from 3,839 avocados, giving an infestation index of 4.3 larvae per 100 fruit. Not all proved to be the Mexican fruit fly. In one collection made in Tapachula, in the state of Chiapas, 48 flies of *A. serpentina* were recovered. This is another species of fruit fly found occasionally in the Rio Grande Valley.

In most collections of avocados a small fly, *Carpolonchaea pendula* Bezzi, belonging to the family of hunchback flies, *Lonchaeidae*, has been recovered in large numbers. This fly is reported to be a scavenger, but in several collections has emerged from sound fruit. In the course of studies on the Mexican fruit fly, *pendula* has been reared from 22 species of fruit, so it has a fairly wide host range.

Three collections of avocados were made in Jungapeo, state of Michoacan, from trees interplanted with mangoes. On the first collection in late March, before the mangoes had matured, 34 Mexican fruit flies were recovered from 445 avocados. In late April a second collection of 1,600 avocados produced only 5 flies, and in early June, at the peak of the mango season, no flies were recovered from 900 avocados. All collections were made from the same general area and included many varieties. These findings indicate that avocados are not a preferred host, but in areas where primary hosts are abundant and develop heavy local fly populations, avocados may become infested when more suitable fruits are not available.

From the results gathered so far there seems to be some evidence of resistance in avocados to insect attack. This phase of the study will be given more attention this year when fruit becomes available. Resistance should not be overlooked when selections are made.

1956 Report of the Experiment Station Avocado Test Plot

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At present 62 strains of avocados are growing in the Experiment Station avocado test plot. Most of these are selections made in northern and central Mexico. There also are a few Florida and California varieties included in the test. The first trees were planted in 1950. Since that time, data were recorded on the fruiting performance of several varieties. Cold tolerance of some strains in the plot was reported (Maxwell, 1950 and 1954) after several freezes in the Valley.

The 1956 growing season in the Lower Rio Grande Valley was excellent for avocados. Several hives of bees were placed near the test plot to facilitate pollination. A good fruit yield was obtained on the older trees including Atlixco 14382 and 14369 and on some of the younger trees that had not set fruit before (Table 1). Other young trees, including several other Atlixco strains, had only a few fruit.

The heaviest yield obtained was 134 pounds on a six-year-old Booth 8 tree. In past seasons, this same tree yielded fruit that weighed 15 to 30 ounces but in 1956 the crop was so heavy that the tree could not properly mature it and the average size was 10 ounces.

The following strains showed the most promise for Valley conditions for home garden or commercial planting: Castro, Diaz, R No. 1, Lula and Booth 8. Two Atlixco strains, 14382 and 14369 had fair fruit crops and were outstanding in flesh texture and flavor. Since this is the first year that they fruited, it will necessary to observe them several years before recommendations can be made as to their adaptability. Arsola 29/9 fruited for the first time in the Valley and was of excellent quality. However, several years data in the Valley are needed before its adaptability can be determined.

Table 1. Characteristics of some avocado strains in the Experiment Station test plot during 1956.

Variety	Average No. lbs. fruit per tree	Fruit weight ounces	Seed weight ounces	Fruit Characteristics: Color	Shape	Flavor	Anthracnose occurrence*	Harvest period	Tree age (yrs.)	Location parent tree	Race of avocado
Castro	37	5	1.2	Black	Pyriform	Nutty	2	June, July	5	Victoria, Mex.	Mex.
W #1	31	5	1.3	Black	Pyriform	Nutty	2	July	5	San Juan, Tex.	Mex.
Alaniz #3	4	5	1.0	Black	Pyriform	Nutty	4	July	5	Llera, Mex.	Mex.
Arsola 12/5	2	7	1.6	Black	Round	Nutty	4	July	3	Llera, Mex.,	Mex.
Arsola 29/9	2	12	2.8	Green	Pyriform	Nutty	1	July	3	Llera, Mex.	W.I.xMex.
Arsola 17/3	11	6	2.0	Black	Pyriform	Nutty	3	July, Aug.	3	Llera, Mex.	Mex.
Diaz	61	8	2.0	Purple	Oval	Nutty	1	July-Sept.	6	Victoria, Mex.	W.I.xMex.
Santa Engracia	3	10	2.5	Purple	Pyriform	Nutty	4	July, Aug.	6	Victoria, Mex.	W.I.xMex.
Arsola 1/18	14	12	3.5	Green	Oval	Nutty	4	Aug.	5	Llera, Mex.	W.I.xMex.
R #1	60	8	1.6	Black	Oval	Nutty	2	Aug., Sept.	5	Raymondville, Tex.	Mex.
McRill	31	15	3.6	Green	Pyriform	Sweet	1	Aug., Sept.	6	McAllen, Tex.	W.I.
Atlixco 14382	15	9	1.1	Green	Pyriform	Nutty	2	Aug., Sept.	6	Atlixco, Mex.	Mex.
Atlixco 14369	21	10	2.0	Green	Oval	Nutty	1	Nov., Dec.	6	Atlixco, Mex.	Guat.
Lula	65	12	3.0	Green	Pyriform	Sweet	1	Oct.-Dec.	6	Florida	W.I.xGuat.
Booth 7	27	15	3.5	Green	Round	Sweet	1	Oct., Nov.	6	Florida	W.I.xGuat.
Booth 8	134	10	1.5	Green	Obovate	Sweet	1	Nov., Dec.	6	Florida	W.I.xGuat.

* Anthracnose Occurrence
1 None
2 Present in wet years
3 Very susceptible
4 No determination

Preliminary Studies On Low Temperature Ripening of Avocados For Control of Anthracnose

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Commercial production of avocados in the Lower Rio Grande Valley is hampered by a number of factors. The varieties and hybrids currently in production are either very susceptible to low temperatures, have low salt tolerance or are susceptible to anthracnose rot. Until a variety is developed which is tolerant of or resistant to these conditions, cultural and handling practices which will offset these deficiencies are needed.

Because of its cold-hardiness, the Mexican race of avocados has been explored by the Texas Avocado Society for selections which may be adapted to the Lower Rio Grande Valley. This race is particularly susceptible to anthracnose rot however. If this disease can be adequately controlled several of these selections show promise for commercial production in this area. Attempts at field control of this organism have not been successful.

Since the disease does not usually appear on the fruit until after it has been harvested (except with highly susceptible varieties) the idea developed that possibly it could be controlled after the fruit is harvested.

During the 1955 season several fungicidal dips were used in an attempt to control anthracnose rot but they proved ineffective.

Preliminary tests conducted during the 1955 and 1956 season with fruit from several selections of the Mexican type avocado strongly suggest that ripening at low temperatures will control anthracnose rot of avocados. Ripening at 55° to 60° F. has practically eliminated the appearance of anthracnose, whereas, ripening at 80° has resulted in severe infection of the fruit by this organism. There is usually 100 per cent infection at the end of 3 to 4 days at 80°. Avocados ripened at 55° to 60° have held up well for as long as four weeks.

This method of ripening avocados has been successfully used by one producer during the 1956 season.

Further testing of this procedure will be continued using fruit from all varieties and seedlings that show promise of commercial adaptation to Valley conditions.

Preparation of a Frozen Avocado Mixture For Guacamole

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Avocados (*Persea americana* Mill.) are produced in quantity in Florida and California, (USDA Agricultural Statistics, 1954; California Avocado Society Yearbook, 1953-54), and, if present plantings mature, avocados will become an important commercial crop in the Rio Grande Valley of Texas. Seedlings of the Mexican race, which according to Hodgson (1947) are cold-tolerant, are being planted throughout the Valley, with largest plantings in the Rio Grande City area. Some of these seedlings appear to be fairly resistant to certain diseases. Most of the trees in this area originated from chance seedlings found in the Rio Grande Valley and northern Mexico. There are a few seedlings of the Guatemalan and West Indian races and some hybrids which are being grown in test plantings.

Local nurserymen and future grove owners have requested information about ways in which avocados may be processed in event a sizeable avocado industry is developed in the Valley. Under these circumstances there would be a quantity of fruit which would make an excellent food product but which could not meet market standards for fresh fruit because of wind scars, damaged spots, small size, and other minor physical defects.

Cruess, Gibson, and Brekke (1951) observed that, "sieved or finely ground avocado flesh mixed with one part by weight of sugar to three parts of fruit kept well when frozen in well filled hermetically sealed cans and stored at 0° F. In cartons or other packages accessible to air, browning and off flavor developed."

McColloch, Nielsen and Beavens (1951) recommend making an avocado spread using 100 parts of avocado puree, 8 to 10 parts lemon or lime juice, 1 to 2 parts salt, and 3 parts dehydrated onion powder. This spread retained a satisfactory color and flavor for a year when stored at 0 to -10° F. Attempts to substitute citric acid for lemon juice, or a mixture of citric acid and ascorbic acid, resulted in a product of less desirable flavor and color retention.

A similar mixture made with Valley-grown avocados resulted in a good sandwich spread, but was acid and too finely divided to resemble the salad the Mexican people call "Guacamole." However, a satisfactory guacamole "base" was made by mashing the avocados into a coarser textured product, using less lemon juice and adding fresh chopped onions instead of onion powder. The term "guacamole base" is used because

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good guacamole salad has many and varied ingredients, depending upon the household recipes handed down from mother to daughter.

A new product, Avocado Whip, developed by Stahl, and reported in Industrial South (1955) combines avocado, onion, lime juice, salad dressing, and salt into a puree suitable for freezing. In a consumer preference questionnaire, 99% of the people who purchased Avocado Whip said they would buy it again. Marketing trial samples were frozen in six-ounce tin cans.

The investigators whose publications have been briefly reviewed, were concerned principally with the development of avocado products. Their experimental work did not emphasize the method of packaging—particularly with reference to replacement of the headspace air in hermetically sealed containers with a vacuum or an inert gas. Neither did their work emphasize the importance of the variety of avocado. The exploratory experiments reported in this paper, on the other hand, are intended to reveal how such variables as method of packaging and variety may affect the quality of an avocado product such as a guacamole base.

MATERIALS AND METHODS

The avocados used in the experiments were grown in the Lower Rio Grande Valley within a radius of 20 miles of Weslaco, and represented varieties and strains of potential commercial importance in the area. Sound ripe fruit was used in the preparation of the guacamole base. It was weighed, washed, hand peeled, and all discolored spots, damaged portions, and seeds removed. The edible portion, seeds, and trimmings were weighed separately and the percentage of each determined. Edible flesh was blended with a coarse potato masher and to each 100 parts by weight, was added 5 parts of lemon juice, 4 parts of fresh chopped onion and 1 part salt. This ratio of ingredients, one of several tested in the laboratory, gave a very acceptable guacamole base.

A pH determination was made on the blended avocado flesh before other ingredients were added and also on the prepared guacamole base.

The first experiment was intended primarily to determine the effects of different conditions of packaging on some of the quality characteristics of the frozen stored guacamole base. Several varieties of avocados harvested in January of 1955 were composited to provide sufficient material for 10.5 pounds of guacamole base. Immediately upon preparation, 2 pounds was dispensed in single strength polyethylene bags,* approximately 8 ounces per bag. Excessive air was removed and the bags were promptly sealed and frozen in still air at 0° F. The remainder of the base was dispensed in glass jars, 14 ounces to the jar, 9 jars in all. Approximately 3/16 inch headspace was left in each jar for expansion of the guacamole base. Three jars were sealed with 1-piece screw-type lids, without further treatment, i.e. without deaeration. The lids were loosely

* Commonly used for household frozen food storage.

fitted on three of the remaining six jars and these were placed in a large vacuum desiccator for 3 minutes. As air was released back into the desiccator the lids sealed the jars. The lids were loosely fitted on the other three jars and placed in a vacuum desiccator for three minutes. Nitrogen was released into the desiccator, then the top removed and the jars sealed. The jars were also frozen and stored in still air at 0° F.

The second experiment was intended primarily to determine the effect of variety or strain on the yield and quality characteristics of a guacamole base. Advantage was taken, however, of the opportunity which it provided to obtain additional information on the effects of packaging on quality.

Twelve varieties and strains of avocados were harvested in August 1955. A guacamole base was prepared from each variety or strain as described and a portion of each dispensed into 4-ounce plain tin cans (8 cans per variety). The remainder of the guacamole base for each variety or strain was placed in bulk in a large vacuum desiccator, vacuum applied for 3 minutes, then carefully dispensed in 4-ounce plain tin cans (16 cans per variety). The lids were placed on 8 cans of each variety or strain and these put back into the vacuum desiccator and deaerated for 1 minute, removed and sealed. The remaining 8 cans were handled in the same manner except nitrogen was released in the vacuum desiccator prior to sealing the cans. As in the preceding experiment, all canned samples were frozen and stored in still air at 0° F.

Samples of guacamole base made in January and packaged in polyethylene bags and glass jars were evaluated for flavor differences at the end of 3 and 7 months storage intervals. Care was taken to mask the color so it would not influence the flavor evaluation given by the panel of nine judges. Each judge was given 3 portions of guacamole base from the glass jars; one portion from a vacuum pack, one from a nitrogen pack, and one from an undeaerated control. He selected the portion he liked best and described those of particularly poor flavor as rancid, bitter or acid. If he could detect no differences among the portions he was asked to write "no difference" on his evaluation card. The test was repeated three times with different arrangements of the portions. The guacamole base packaged in polyetheylene bags was presented as a fourth sample for only the first test.

Samples of guacamole base made in August and packaged in plain tin cans were examined for changes in flavor which might be attributable to packaging in the same manner as undertaken with the glass jars. Each judge was given 3 portions at a time of each variety or strain, one from a vacuum pack, one from a nitrogen pack, and one from an undeaerated control.

Representative portions of the undeaerated control made from each of the 12 varieties and strains were arranged in a row. The judges mutually agreed on one as a preferred sample or "control," then compared the others with this as to flavor, color, and consistency. Consistency was judged as the amount of breakdown and separation which occurred during frozen storage and subsequent thawing. The samples were judged as excellent with a value of 4 points, good 3 points, fair 2 points, or poor 1 point. The test was repeated 3 times with different arrangements of the samples. The scores given by the judges were averaged and each sample given a numerical value for comparison.

A portion of the undeaerated control samples made from each variety or strain of avocado was transferred to a paper cup without a lid and stored at 35 to 40° F. Examinations for discoloration were made after 12 hours and again after 72 hours storage.

RESULTS AND DISCUSSION

A composite sample of guacamole base was prepared and packaged in single strength polyethylene bags and vacuum packed samples, nitrogen packed samples and undeaerated control samples packaged in glass jars. At the end of a 3-month storage period at 0° F. each member of a taste panel consistently rated samples packaged in single strength polyethylene bags as having a rancid flavor (Table 1). The off flavor was so pronounced that further storage tests of guacamole in polyethylene bags was discontinued. The bags used in this evaluation were single strength and did not prevent the development of discoloration and off flavor during storage.

The same judges could detect no differences after 3 months' storage between the composited samples packaged in glass jars, or the guacamole base made from the varieties and strains and packaged in tin cans (Table 1).

At the end of 7 months' storage, 7 of the 9 judges could consistently detect an off flavor in the vacuum packed samples in glass jars which they described as rancid. Two of the judges could detect an off flavor only 66% of the time. The method of vacuum packing the samples in glass jars probably is responsible for the off flavor. As the air was removed in the vacuum desiccator, the guacamole pulled apart leaving hundreds of small open pockets or "bubbles" throughout the mixture. The jars were sealed under vacuum, therefore the small open pockets remained during the storage period and discoloration occurred adjacent

Table 1. Flavor in samples of Guacamole Base observed when method of packaging is the major variable.

		Storage at 0° F					
		3 months			*7 months*		
Sample	*Container*	*Control*	*Vacuum*	*Nitrogen*	*Control*	*Vacuum*	*Nitrogen*
Composite	Polyethylene bags	R*	—	—	—	—	—
Composite	Glass jars	ND**	ND	ND	ND	ND	R
All varieties	Tin cans	ND	ND	ND	ND	ND	ND

* Rancid
** No difference

to each open space. This condition did not exist with the nitrogen packed samples because as the nitrogen was released into the vacuum desiccator, the small air pockets were compressed from the guacamole base.

The judges could detect no differences due to packaging in any of the other samples at the end of 7 months storage, whether it was the composited mixture or the guacamole made from the varieties and strains.

The second experiment designed to determine the effects of varieties or strains on yield and quality showed a yield difference (Table 2) as much as 30.4% in the amount of edible portion and that quality of guacamole as determined in this experiment, varied considerably among the varieties and strains.

The Topa variety, a large fruit with a relatively small seed, yielded 71% flesh, while the Y-7 strain, the smallest fruit tested with the largest seed, yielded only 40.6% flesh. The seed of the Y-7 adhered tightly to the flesh, making preparation of a guacamole base difficult.

There was little difference in pH of the fresh fruit, and the addition of lemon juice, chopped onion and salt to each variety or strain lowered the pH from about 6.4 to 4.6 (Table 2). During the sensory evaluation the same three judges commented each time that guacamole base made from the Paz variety appeared to taste slightly acid but was not objectionable. According to Table 2 the pH of Paz does not differ appreciably from that of any other variety.

At the end of 3 months storage and again at the end of 7 months storage all judges rated guacamole base made from the Y-7 strain as having the best flavor and color (Table 2), and was equalled only by Topa variety in consistency. With the exception of 19-1 strain and Topa variety, there was little difference in the flavor of any one variety or strain from the 3-month storage period to the 7-month storage period. The 19-1 strain had become slightly rancid, therefore was given a rating of poor at the end of 7 months storage. The Topa variety was given an increased flavor rating from 2.4 at the end of 3 months storage, to 3.3 at the end of 7 months storage (Table 2).

The color evaluation of all varieties and strains, except Paz variety, was about the same at the end of 7 months storage as it was at the end of 3 months storage. The Paz variety had darkened somewhat at the end of 7 months. This could have been due to differences in maturity at the time of processing, or it was more susceptible to oxidation than the other varieties or strains.

The color of guacamole base made from 16-5, Y-6 (Pancho) and C-3 strains was light green. Amidon variety was yellow green, and 21-6 blue green. These four strains and one variety were rated less desirable in color than the other six varieties and strains tested, but all would make a commercially acceptable guacamole base.

The consistency of some varieties and strains was thick butter-like and retained this characteristic through frozen storage, while others

Table 2. Yield and Quality of Guacamole Base from several Avocado varieties and strains.

Variety or Strain	Flesh %	Seed %	Peel %	pH		Sensory evaluation[1]					
						3 mo. storage			7 mo. storage		
				Fresh Fruit	Guacamole Base	Flavor	Color	Consistency	Flavor	Color	Consistency
Topa	71.0	12.3	16.7	6.7	4.5	2.4	3.3	3.4	3.3	3.2	3.3
16-5	68.7	19.3	12.0	6.4	4.5	2.2	1.9	1.8	2.0	2.2	1.6
19-1	65.5	25.9	8.6	6.4	4.4	2.0	2.3	3.1	1.1	2.0	2.6
Y-6 (Pancho)	61.4	23.6	15.0	6.2	4.4	2.7	1.6	2.2	2.0	1.7	2.0
Diaz	61.0	19.5	19.5	6.5	4.5	—	—	—	—	—	—
Santa Engracia	59.6	23.1	17.3	6.5	4.5	2.8	2.0	2.2	2.8	2.3	2.2
Lulu	59.1	24.8	16.1	6.3	4.6	2.9	2.7	2.6	2.8	2.8	2.4
Paz	58.5	19.5	22.0	6.4	4.4	2.6	2.8	2.2	2.5	2.0	3.0
R-1	57.4	20.1	22.5	6.7	4.8	—	—	—	—	—	—
Amidon	56.7	27.7	15.6	6.3	4.6	2.2	1.6	2.6	1.8	1.7	2.8
C-3	52.2	29.3	28.5	6.3	4.5	1.4	1.8	2.2	1.5	2.0	1.8
21-6	44.0	44.9	11.1	—	4.4	1.2	1.8	2.6	1.0	1.6	2.4
Y-7	40.6	41.8	17.6	6.6	4.7	3.6	3.6	3.0	3.7	3.7	3.5

[1] The numbers represent numerical opinions of the judges: 4 Excellent, 3 Good, 2 Fair, 1 Poor

became soft and a thin watery phase separated from the guacamole base. The Topa variety and 19-1 and Y-7 strains retained their thick consistency, while 16-5 strain became very mushy and watery. The Santa Engracia and Paz varieties and Y-6 (Pancho) and C-3 strains were softer after freezing and thowing than before, but would be commercially acceptable for a guacamole base.

The Lulu variety yielded 59.1% edible portion and the guacamole base made from this variety was slightly above average in flavor, color and consistency (Table 2). This variety is specifically mentioned because it appears to be adapted to the climate and soil in this locality and constitutes large percentages of present plantings.

The color of some varieties and strains darkened badly when exposed to air during refrigerated 35°-40° F. storage, while others changed very little. The C-3 and 19-1 strains darkened considerably after 12 hours' storage and the Topa and Paz varieties and the Y-6 (Pancho), Y-7 and 21-6 strains did not discolor after 12 hours. After 72 hours storage the Santa Engracia variety and Y-6 (Pancho) strain were the only samples which had not discolored.

The sensory evaluation of the Diaz variety and R-1 strain were not included in Table 2 because the fruit of these two varieties ripened unevenly. Apparently the fruit was harvested too green because the stem end would decay before the distal end ripened. Although care was taken to select sound fruit, some were used which were too green; consequently, the guacamole base was bitter. This condition is not a regular characteristic of the Diaz variety or R-1 strain.

SUMMARY

An acceptable guacamole base was prepared by blending 100 parts by weight of avocado flesh with 5 parts of lemon juice, 4 parts fresh chopped onion and 1 part salt.

The guacamole base kept well for 7 months at 0° F. storage, when packaged with minimum headspace in glass jars or plain tin cans.

Samples packaged in polyethylene bags were discolored and rancid at the end of 3 months storage.

Glass jars of guacamole base which had been sealed under vacuum developed open spaces or "bubbles" throughout the mixture, permitting discoloration and off flavor at the end of 7 months storage.

The amount of edible portion of the varieties and strains tested, varied from 71% to 40.6%.

Under the conditions of these tests the Topa variety rated high for making guacamole base and the C-3 and 21-6 strains were the poorest. The Y-7 strain made the most flavorable and best colored base, but unfortunately was the lowest in yield of edible flesh and was the most difficult to prepare.

Some of the varieties and strains tested retained a butter-like consistency after frozen storage, while others became very mushy and a watery phase separated from the thawed mixture.

After 72 hours storage exposed to air at 35-40° F. the Santa Engracia variety and Y-6 (Pancho) strain were the only samples which did not discolor.

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GRAPE SECTION

M. R. Campbell—*Section Chairman*

Girdling Seedless Grapes in the Rio Grande Valley of Texas

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Thompson Seedless and Perlette grapes are the most promising Vinifera varieties for the Rio Grande Valley of Texas. Both varieties produce seedless, early-maturing, small-berried grapes. However, the general public prefers a large berry; therefore methods to increase berry size have been studied for many years in Vinifera grape growing regions. Girdling the vines at a certain stage of growth of the berry has been found to increase the berry size of seedless grapes. The method and its limitations in California has been described by Jacob and Winkler (1950).

The objective of the present experiment was to determine the effect of girdling on grapes in the Lower Rio Grande Valley. Five vines of Perlette on Dog Ridge and 5 vines of Perlette on La Pryor rootstocks were trunk girdled with a 3/16 inch wide girdle on April 11, 1956. The berries, at the time of the girdling, were approximately the size of buckshot. The bunches were also "berry-thinned" at the time of girdling because California experience indicated that increase in berry size by girdling would make the bunches too compact unless they were thinned. The control plot consisted of 5 vines of Perlette on Dog Ridge and 5 vines of Perlette on La Pryor that were not girdled or berry thinned.

Twelve vines of Thompson on Champanel rootstock were cane-girdled on April 18 with a 3/16 inch girdle when the berries were the size of buckshot. The bunches were also berry-thinned by cutting off the tail and allowing 5 or 6 shoulders to remain. Seven vines of Thompson on Champanel that were not girdled or berry-thinned were used as the control plot.

Observations were made on the rapidity of healing across the girdles on both Thompson Seedless and Perlette. On May 9, 1956 the girdles on both varieties were nearly calloused over and by June 1 all girdling wounds were entirely healed.

Sampling of the bunches of grapes was accomplished by pulling 200 berries at random without regard to size from a large number of bunches. The gram weight of each 200 berry sample was recorded. The sample was then crushed in a mortar and the per cent total solids was determined with a refractometer.

The size of the berries from the girdled vines was 27.4 to 34.5 per cent larger than the size of berries from ungirdled vines (Table 1). The total solids apparently were not affected by the girdling operation. The small difference between percentage of total solids of berries on girdled and ungirdled vines of Perlette on La Pryor is attributed to the method of sampling.

Table 1. Berry size and total soluble solids of girdled and ungirdled grapes.

Variety	*Rootstock*	*Vine Treatment*	*Date Harvested*	*Weight of 200 Berries gms.*	*Total Solids %*	*Increase in Berry Size Girdled over Non-Girdled Vines %*
Perlette	Dog Ridge	Trunk Girdled	5/18/56	411	18.9	27.4
Perlette	Dog Ridge	Not Girdled	5/18/56	298	18.9	
Perlette	La Pryor	Trunk Girdled	5/18/56	436	17.8	29.5
Perlette	La Pryor	Not Girdled	5/18/56	307	18.5	
Thompson	Champanel	Cane Girdled	6/15/56	411	21.0	34.5
Thompson	Champanel	Not Girdled	6/15/56	269	21.2	

These results represent only one year's work and can not be considered conclusive. They do agree with the California results on girdling on Thompson and Perlette. One grower in the Laredo area has increased the berry size on Thompson on Champanel in the 1955 and 1956 seasons by both cane girdling and trunk girdling.

Studies on girdling over a longer period of years are needed to determine the extent of berry size increase expected in different growing seasons. Additional work is planned to find the effect of girdling at different stages of growth of the berry and the effect of girdling on heavy versus light crops of grapes.

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VEGETABLE SECTION

Walter Baxter—*Section Chairman*

The Response of Carrots to Fertilizer Applications

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Texas leads all other states in the production of winter carrots. The acreage planted to carrots in Texas each year ranges around 25,000 acres and is valued at 3-4 million dollars a year. The majority of this acreage is grown in the Lower Rio Grande Valley area.

In 1952 an experiment was conducted at the Valley Experiment Station to determine the response of carrots grown in a loam soil to applications of commercial fertilizers. The results of that experiment are given in this report.

Methods and Materials

The treatments included 0, 40 and 80 pounds each of nitrogen (N) and phosphoric acid (P_2O_5), and 0 and 80 pounds of potash (K_2O). These treatments were used singly and in all possible combinations making a total of 18 different treatments.

Nitrogen was from ammonium nitrate (33.5% N), phosphoric acid from super-phosphate (45% P_2O_5) and potash from muriate of potash (60% K_2O).

The fertilizer materials were applied in the center of the beds 3-4 inches below the seed zone. Carrots of the variety Imperator were seeded two rows on each bed the middle of October.

The test design was a 3x3x2 complete factorial with four replications. Each plot consisted of four double rows 50 feet long. The two middle rows of each plot were harvested for yield data.

All carrots were harvested in February and were culled, graded and weighed in the field.

Results and Discussion

Data in Table 1 show that the application of 40 pounds nitrogen resulted in a significant increase in the yield of marketable carrots. The addition of more than 40 pounds of nitrogen did not cause further yield increases. Nitrogen fertilization tended to increase the percentage of medium size carrots and decrease the percentages of small and large carrots. The medium size has a greater demand for the fresh market.

The application of phosphate fertilizers did not result in yield increases and no consistent trend in size distribution was found as a result phosphate fertilization.

Potash applications did not effect yields or size distribution of the carrots.

Table 1. Main effects[1] of different levels of nitrogen, phosphoric acid and potash on the yields[2] and size distribution of marketable carrots.

Total pounds of nutrients per acre in fertilizer	Bushels per acre of topped carrots	Size distribution in percent of total		
		Under 1 in. diameter	1-1½ in. diameter	Over 1½ in. diameter
		Nitrogen		
0	422	22.5	74.7	2.8
40	476	21.5	76.3	2.2
80	450	20.3	77.6	2.1
L.S.D. .05	28			
L.S.D. .01	37			
		Phosphoric Acid		
0	469	21.5	76.3	2.2
40	461	20.2	77.2	2.6
80	441	22.9	74.9	2.2
L.S.D.	N.S.			
		Potash		
0	458	21.5	76.1	2.4
80	456	21.5	76.1	2.4
L.S.D.	N.S.			

[1] A number representing the main effect of any specific fertilizer nutrient is an average of the effect of all treatments in the test that included that particular level of the nutrient involved.

[2] Yields are reported in bushels (50 lb.) of topped carrots per acre.

SUMMARY

One year's data from a replicated carrot fertilizer test indicate that carrots grown on a loam soil in the Lower Rio Grande Valley respond to nitrogen fertilization. In this test 40 pounds of nitrogen (N) per acre gave maximum production. Carrots did not respond to phosphate and potash treatments.

Current Water Problems in the Lower Rio Grande Valley

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Categorically there are three major water problems, *Supply, Transportation* and *Application.*

Supply—There is a total of 335,500 square miles within the outer rim of the entire Rio Grande basin. However, there is only a total of 155,540 square miles above Falcon Dam that contribute runoff to the flow of the Rio Grande. The rainfall on the remainder of the area within the outer rim of the Rio Grande basin does not reach the main stem of the Rio Grande. Of this 155,540 square miles of contributive or productive drainage area above Falcon Dam, 87,760 square miles are in the United States and 67,780 square miles are in Mexico.

Elephant Butte Dam on the Rio Grande above El Paso controls all flows to permit the El Paso-Juarez Valley to consume all available Rio Grande waters above Fort Quitman, Texas, about 80 river miles downstream from El Paso. The remaining productive area from Fort Quitman to Falcon Dam is therefore reduced to about 36,000 square miles in the United States and 45,000 square miles in Mexico, or a total of about 81,000 square miles. Therefore, approximately 44 er cent of the productive drainage area contributing to Falcon Reservoir is within the United States and 56 per cent within Mexico.

The average annual rainfall on the approximate 36,000 square miles of United States productive area of the Rio Grande watershed in Texas from Falcon Dam to Fort Quitman, Texas for 83 years of record has been about 18 inches or 960 acre feet per square mile. The average runoff from this same productive area above Falcon Dam from 1900 to 1913 was approximately 65 acre feet per square mile or about 7 per cent of the average rainfall, and the average runoff from 1924 to 1953 was about 60 acre feet per square mile or 6 per cent of the average rainfall.

Approximately 30 acre feet of water per square mile was released from Falcon Reservoir in 1954, 26 acre feet per square mile in 1955 and 17 acre feet per square mile in 1956. With more tanks and dams continually being constructed on the productive area above Falcon Dam, the per cent of runoff to rainfall will be still further reduced unless something is done to improve the situation or at least hold our own.[1]

The 83 year record shows the approximate 18 inch average annual rainfall for the productive area above Falcon Dam to have been distributed percentage wise over the months of the year as follows:

Total	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
100%	4	3	4	8	11	12	12	12	14	9	6	5

[1] See "The Rio Grande" by Karl F. Keeler in The Proc. 8th Ann. Rio Grande Valley Hort. Inst. for a more detailed study of the water situation.

Transportation—The river mileage from Falcon Dam to the Gulf of Mexico is about 260 miles and water released from Falcon Dam requires about seven days travel time to reach the Gulf. Inclement weather, equipment breakdowns, channel shoaling, etc., causes flows to occur after the water has been released from Falcon Dam which becomes surplus to our needs.

Approximately three Channel Storage Dams to be constructed in the vicinity of Brownsville, San Benito and Progreso, together with the Tide Water Dam which is already constructed five miles upstream from the Gulf of Mexico and Anzalduas Dam which is under construction, south of Mission, have an extremely favorable benefit to cost ratio and construction of the three additional proposed Channel Storage Dams will provide additional conservation of approximately 200,000 acre feet of additional available Rio Grande water a year. The gravity canal, if and when constructed, will supplement but not replace the Channel Storage Dams as the gravity canal constructed on a sloping grade in event of inclement weather, etc., will require flows surplus to our needs to be sluiced from the gravity canal into the river and also local inflows below Facon Dam occur from rainfall and will continue to flow in the existing river channel to the Gulf.

On June 29, 1956 the State of Texas through the Attorney General and the State Board of Water Engineers, together with cities and municipalities of the Rio Grande Valley of Texas was successful in placing in the jurisdiction of the 139th District Court of Hidalgo County not more than 50,000 acre feet of the United States' share of water in Falcon Reservoir available for release to be used for domestic, municipal and livestock purposes only. Such water was alloted on the basis of 120 gallons per capita per day; 30 gallons per day for head of horses and cattle; 3 gallons per head per day for sheep, goat and pigs ;3 gallons per day per 100 chickens, turkeys, etc. The order permitted establishment of approved water points and allowed 5 per cent per mile for canal losses from the Rio Grande diversion points to the approved water points, and an additional one-fourth of an acre foot per week for preservation of each mile of concrete-lined canals.

On October 17, 1956 after due process of notice of hearing, the Court took all the United States' share of water in Falcon Reservoir available for release and that flowing in the channel of the Rio Grande into the custody of the Court.

On December 8, 1956 after due process of notice of hearing the Court continued by order, judgment and decree the order of June 29, 1956 and approved an interim plan of operation which provided some of the following features:

50,000 acre feet of the United States' share of water in storage in Falcon Reservoir available for release be reserved for domestic, municipal and livestock use.

20 per cent of the total United States' share of water in storage avail-

able for release be reserved for reservoir, channel and other losses.

The remaining United States' share of water in storage in Falcon Reservoir available for release be divided among all acres of land in the Counties of Starr, Hidalgo, Willacy and Cameron being irrigated on or before October 17, 1956 on a pro rata per acre basis.

The allottee be permitted to withdraw such water as he has to his credit at any time so long as he has a credit balance.

The Water Master be restricted from having any interal control of a water district.

Each allottee be permitted to protest to the Court any action of the Water Master.

The Water Master be required to report any alleged violation of the order, judgment and decree of June 29 and December 8, 1956 and approved rules and regulations thereunder by affidavit and if so ordered by the Court the alleged violator be required to appear before the Court and show cause why he should not be cited for contempt.

Application—Application requires economic use by the water user and this is beyond the realm of the duties of the water master. Governmental agencies, farm bureaus, agricultural organizations and many other groups of the Rio Grande Valley have performed some very noteworthy work and accomplished a great deal in the education and instigation of beneficial water conservation measures and they should be commended. However, the manner and resulting efficiency by which the water is actually applied to the land is the major determining factor as to whether or not we will be able to exist on the supply of water we have available.

Stem-End Breakdown of Cantaloupes Caused By *Atherigona Orientalis* Schin.

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During the latter part of May, 1956, the larvae of *Atherigona orientalis* Schin.[1] were found to be causing a stem-end breakdown of cantaloupes grown in the Lower Rio Grande Valley of Texas. Butcher (1954) reported similar injury by the same insect to Florida cantaloupes.

As soon as stem abscission starts on cantaloupes in the field the adult female fly deposits the eggs on the abscissed area of the cantaloupes. The commercial cantaloupes are usually picked at the "half-slip" stage of maturity usually before the eggs had hatched. Larvae emerged from these eggs in about three days after oviposition. The larvae immediately commenced feeding in the flesh of the cantaloupe just below the abscission. The larvae, which are similar in size and shape to the housefly larvae, fed for approximately 7 days and then pupated. The pupation period lasted 5-6 days.

A number of cantaloupes picked at the "half-slip" of maturity were found infested with these fly eggs. These cantaloupes were brought into the laboratory for observation. In approximately 4 or 5 days the feeding of these larvae had caused the stem end of the cantaloupes to break down, which was evident by the large amount of juices dripping from the stem end. This stem-end break-down was similar to that reported by cantaloupe shippers as causing severe losses at terminal markets during the 1954 cantaloupe season.

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[1] Identified by C. W. Sabrosky, Entomology Research Branch, Agricultural Research Service of the U.S.D.A.

Why Tomato Flowers Fail to Set Fruits

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Tomato flowers can set big crops of fruits only when conditions are favorable. Excess nitrogen fertilizer applied when the plants are small can stimulate excess vine growth and unfruitfulness. Hence, good culture includes only moderate fertilization with nitrogen when the plants are small. Abundant nitrogen should be applied when the plants bear many fruits ½ to 2 inches in diameter. Different varieties may respond differently.

Tomatoes are very sensitive to favorable temperatures for developing normal flowers and setting fruits. Following temperatures too warm or too cold, different varieties of tomatoes may require 5 to 10 days to develop normal flowers. Generally, green-wrap tomatoes cannot set many fruits when night temperatures are cooler than 59° F. Very early varieties bred in cool climates may set fruits at 50 to 55°.

Now we have a useful formula for setting temperatures. Dr. S. P. Johnson and W. C. Hall of Texas Agricultural Experiment Station published a report stating: "Temperatures considered favorable range from 55 to 69° at night and 70 to 85° during the day." Abundant in the light far-red range associated with clear summer weather decreases and distorts growth of tomato plants. Cloudy weather, by decreasing far-red light, permits tomato flowers to set fruits at higher temperatures. Pollen commonly is sterile in weather hotter than 90°.

For green-wrap tomatoes in Texas, the formula may be changed slightly to read: 59 to 69° at night and 70 to 86° in daytime, which appear best for setting big crops of tomatoes. Tomatoes need favorable temperatures during both day and night in the same days, and probably at least 8 hours in each of the days. Single isolated days with favorable temperatures in unfavorable periods of time may be ineffective because the plants lack normal flowers. Calculations for TAES Progress Report 1849 were based on periods of 3 or more consecutive days with favorable temperatures. In the two months when tomatoes set most of their commercial crop, apparently they require at least 18 days with favorable temperatures per month to set big crops of fruits. Less favorable temperatures result in smaller crops of fruit.

Tomatoes are being developed that resist heat sterility enough to set fruits at 87 to 93°. Usually most fruits are seedless when they set near 90°. Present selections do not equal Rutgers in quality but they are good enough for local markets. More recent crosses promise fruits approaching Rutgers quality. Of the 40 kinds of tomatoes in the Southern Tomato Exchange Program in 1956, S1860 fruits had the highest rating for ascorbic acid (Vitamin C). It also rated high in earliness and productivity. It may be released as a new variety in 1958 if it continues to perform favorably.

Groups of tomato varieties show different physiological responses. Class A varieties such as Bison are very fruitful but weakly vegetative. Usually they are very early with a high ratio of fruits to leaves but poor shade. I saw a Bison tomato plant bear a pile of about 1/3 bushel of fruits surrounded by a ring of leaves. Class B varieties such as Pritchard and Bonny Best are fruitful and moderately vegetative but may not shade their fruits well enough. Pritchard is a low-metabolism variety with some tolerance for high temperatures. It needs high-nitrogen soil and gets little value from late application of fertilizer. Class C tomatoes like Marglobe are fruitful and strongly vegetative. Class D tomatoes (Rutgers) are moderately fruitful and very strongly vegetative. They have high-metabolism plants that grow best at moderately low temperatures and are injured most by high temperatures. Rutgers responds favorably to late application of fertilizer. It is susceptable to crease-stem (bunchy-top) when it grows in warm moist soil with abundant nitrogen before mid-season.

Strong dry winds and sand storms commonly damage tomato flowers too badly to set fruits. Abundant rains or sprinkler irrigations may prevent opening of the anthers in tomato flowers or wash the pollen grains off the anthers before they can germinate and fertilize the ovules.

Diseases such as early blight, gray leaf spot and bacterial spot (nail-head rust) commonly attack tomato fruit trusses and kill the flowers or damage them too badly to set fruits. These diseases can be prevented by spraying or dusting the plants with copper such as Microgel or Copper-A Compound soon, often and thoroughly enough. Abundant thrips in the flowers can prevent pollination. However, thrips are rare in fields well treated with DDT.

Tomatoes yield best when they are grown as early as favorable weather usually prevails. Using these principles of modern scientific agriculture can add much to profits and avoid common large losses.

Response of Tomatoes to the Organic Fertilizer and Soil Amendment, Fertilaid

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A comprehensive test of the organic fertilizer, "Fertilaid," was conducted on Rio Farms in the spring of 1956, with tomatoes as the test crop. Preliminary trials with various crops had indicated that this material provided something in the way of a benefit to the soil that inorganic fertilizers alone did not provide. Fertilaid is a combination organic fertilizer and soil conditioner. It analyzes 4-2-0 plus supplementary minor elements, and contains 40 per cent humus. It has a pH of about 4.5. It contains organic acids and protein molecules which are the end product of organic decomposition and which are colloidal in size. Determination of the value of Fertilaid for improving tomato production was the main objective of this test, the plots with which it was to be compared having identical treatments except for this factor.

The test area was 6.34 acres consisting of eleven wind-break stripped pans, ten tomato rows to the pan, and rows five feet apart. All of the ground was fertilized prior to planting with 300 pounds per acre of 13-39-0 inorganic fertilizer applied in a band about five inches away from the line of planting, and three inches below the depth of planting. The organic, Fertilaid, was then applied at the rate of 300 pounds per acre in a band two inches above the inorganic fertilizer on five rows in each of the ten row plots. The tomatoes were planted on January 26, 1956, and were up to a good stand a week later. They were side dressed with ammonium nitrate at 150 pounds per acre when the plants began to set fruit. Insecticidal and fungicidal applications were made as needed. Striking differences in plant vigor were seen during the growing season.

Yield records were taken separately from standard fertilization plots and standard plus Fertilaid plots. The total production records were taken in three categories: pink tomatoes, green-wraps, and cannery tomatoes, the culls being discarded in every case.

The tomatoes were harvested throughout by a commercial crew and were taken to the shed, where culls were discarded and the yields weighed. The pink tomatoes were harvested between May 14 and May 25 at one to three day intervals. The green-wraps were harvested May 25, 28 and 29. The ripe tomatoes picked for canning were harvested between June 4 and June 19 at one to three day intervals. At every harvest the Fertilaid plots yielded a greater poundage than the standard inorganic fertilizer alone. The total yields reduced to pounds per acre, in each category of ripeness, are shown in Table 1.

DISCUSSION AND CONCLUSIONS

It appears that Fertilaid plays an important role in the phosphorus

Table 1. Yields of pink tomatoes, green-wraps, and canning tomatoes, in pounds per acre.

Ripeness Class	*Standard Fertilizer plus Fertilaid*	*Standard Fertilizer Alone*	*Increase From Fertilaid Lbs.*
Pink Tomatoes	644	315	329
Green-wraps	4287	2474	1813
Canning Tomatoes	6485	4299	2186
Total Yield	11416	7088	4328

The addition of 300 pounds per acre of Fertilaid increased the total yield by 61%.

nutrition of the plant (Correa and Otey 1956). Phosphorus, up to now in our area, has been of uncertain value to the plant due to the high pH and high calcium content of the soil. By analysis, Fertilaid is high in humus and humic acid, which can hold approximately six times the amount of basic ions in solution as can clay (McGeorge 1930, and Turner 1932) depending upon the rate of oxidation (Norman and Peevey 1939). Also, since they are colloidal in nature in this material, the humus and humic acid can maintain an acid environment around the phosphorus. This would increase its period of availability, enabling the plant to make more efficient use of phosphorus and other minerals. In addition it is known that humus will reduce leaching of the plant food into the subsoil when heavy rains occur or when irrigation water is applied.

Conclusions, in their application to the present study, appear to be justified by the results shown, as follows: The addition of 300 pounds per acre of Fertilaid, at an increase in cost of about $10.00 per acre, increased the total yield of tomatoes by 4,328 pounds per acre of marketable fruit, or 61 per cent over the standard fertilizer check.

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Occurrence of the Tomato Pinworm in the Lower Rio Grande Valley of Texas

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The tomato pinworm, *Keiferia lycopersicella* (Burck),[1] was found for the first time in the Lower Rio Grande Valley of Texas on December 28, 1955. Four out of 7 fields examined had 60 per cent or more of the ripe tomatoes infested with pinworms. Only tomatoes that were ripe or nearly ripe were infested.

Mature pinworm larvae were about one quarter inch in length and were greenish purple in color. They were very active. The pinworm larvae, usually one to a fruit, had entered the fruit at the stem end and had eaten numerous burrows throughout the core of the tomato. Webbing and frass were noticed many times in the burrows. The internal injury is difficult to detect.

A fall tomato season very seldom lasts into the latter part of December because of light frost which usually occurs during the latter part of November or the early part of December. No frost occurred during the 1955 growing season and because of this the tomato season was prolonged and allowed the tomato pinworms to build up to destructive numbers.

The tomato pinworm is one of the most destructive tomato pests in California, according to Essig and Hoskins (1944), and must be considered a potential problem to tomato canners in this area.

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[1] Identified by Paul T. Riherd, Mercedes, Texas.

Commercial Control of the Tropical Mite on Tomatoes and the Two-Spotted Spider Mite on Strawberries

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The tropical mite, *Tetranychus marianae* McG., was first found in destructive numbers on mature tomato plants in the Lower Rio Grande Valley during May, 1956 (Wene 1956). Since that time these mites have been found in damaging numbers on mature tomatoes in the Laredo and Yoakum areas during October, 1956. In September 1956 these mites were found in large numbers on recently transplanted tomato plants in the Rio Grande City area. The population was so great that untreated plants were killed by this mite. Night-shade was also found heavily infested with this mite during the winter months of 1956-57.

Due to the heavy infestations of the tropical mite on the young tomato plants a 5-acre block was sprayed with demeton at 0.25 pound per acre. Another 5-acre block was sprayed with trithion at 0.5 pound per acre. Two untreated rows were left as a check area. The infestation before spraying was so heavy that the mite population averaged 50 or more individuals per leaflet. One week after the treatments, an average of 0.7 mites per leaflet were found in the demeton plots and 0.2 mites in the trithion plots. At this time the untreated tomato plants had been killed and an estimated population of 200 tropical mites were found on night-shade leaves. Three weeks after treatments, an average of 0.5 mite per leaflet was found in the demeton plot as compared with 8.3 in the trithion plot. Also the plants had made a good recovery from the tropical mite injury. It is also interesting to note that in a field across the road which also was heavily infested, two application of parathion spray at 0.25 pound per acre at a three day interval failed to control these mites and the grower had to resort to demeton in order to bring the infestation under control on the small plants.

Two-Spotted Spider Mite On Strawberries

The two-spotted spider mite, *Tetranychus telarius* (L.), was found infesting strawberry leaves during the harvesting period in the Rio Grande City area. Leaf counts showed an average of 2.4 mites per leaf with the heaviest infestation on those leaves close to the ground. A high volume sprayer was equipped so that 4 spray nozzles were directed towards each plant in each row. The sprayer applied 85 gallons of finished spray per acre. Phosdrin was applied to a five acre section at the rate of 0.15 pound per acre. Data taken two days later showed a 95 per cent reduction in the two-spotted spider mite population. A week after the first treatment application all but 16 rows were again retreated with phosdrin at the same rate. Data taken one week later showed an average of 14 spider mites per leaf in the untreated area while only 1.7 were

found in the area which received the second treatment. Both areas were retreated with phosdrin and the data indicated a 93 per cent reduction in the two-spotted mite population. These data indicate that phosdrin can control the two-spotted spider mite but repeated applications are required since phosdrin does not have the residual effectiveness characteristic of a number of other organic phosphates.

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Comparison of Individual Ear Methods of Earworm Control

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Economical control of the corn earworm, *Heliothis zea* (Boddie), has not been obtained generally in Texas by growers with the use of the fixed boom sprayer as described by Blanchard *et al.* (1950). In order to produce a good quality sweet corn in the Lower Rio Grande Valley the crop must be irrigated frequently from the time it begins to silk until harvest. This keeps the soil wet; consequently many growers have found it impractical to keep sprayers operating on schedule. Since a more convenient control operation is needed, tests on the application of DDT dust with the stencil brush was continued as described by Anderson *et al.* (1951), and the sponge application of DDT and mineral oil as described by Wene and Blanchard (1953).

METHODS AND MATERIALS

A 2-inch paint stencil brush was used in applying the various DDT dust formulations listed in tables 1 and 2. The insecticide is applied by dipping the brush into the DDT dust and then pressing the brush in the silk mass. In the first experiment the 3 following DDT dust formulations were used: 10 per cent DDT dust; one part 10 per cent DDT mixed with 2 parts of cotton seed meal; two parts of 10 per cent DDT with 1 part cotton seed meal. The first application of these dust mixtures was made when 24 per cent of the sweet corn had produced silks. The number of applications made and the interval between applications are shown in table 1. Six days after the first stencil brush application was made the silks in one series of plots were sponged with a solution of 1 per cent DDT and 99 per cent mineral oil. The insecticide application was made by dipping a small synthetic sponge in the DDT-oil solution and then pressing this sponge on the silk mass until approximately 1 cc of the solution drained into the silk mass. Each plot included a single row of corn 25 feet in length. Each treatment was replicated 4 times.

In the second experiment the stencil brush treatments were started according to the percentage of sweet corn plants silking. The treatments and the time of the first treatment application are shown in table 2. The stencil brush applications were made at 2-day intervals. A series of plots was also sponged with the DDT-mineral oil solution 8 days after the first silk appeared in the field. A plot consisted of a single row of corn 25 feet in length. Each treatment was replicated 4 times.

In the third experiment an attempt was made to reduce the amount of oil damage to the ear tips resulting from the sponge applications of the 1 per cent DDT-99 per cent mineral oil solution. Water was substituted for part of the oil. The formulations tested are shown in table 3. The water and oil emulsions were unstable and required constant shaking

Table 1. Effect of time intervals and number of applications of DDT on earworm control.

Material and method of application	*No. of applications*	*Day interval between applications*	*Percent worm-free ears*
10% DDT, Stencil brush[1]	4	2	89
	6	2	95
	3	3	80
	4	3	83
	3	4	59
1 part 10% DDT with 2 parts cotton seed meal, stencil brush	4	2	80
	6	2	90
	3	3	90
	4	3	90
2 parts 10% DDT with 1 part cotton seed meal, stencil brush	6	2	69
	3	3	80
	4	3	65
1% DDT in 99% oil, sponged on[2]	1		88
Untreated			0

[1] The first application of the stencil brush treatments were made on April 28, 1955, when 24 percent of the plants were showing silks.
[2] The treatment was applied on May 4, 1955.

Table 2. Relationship of sweet corn silking to the first stencil brush application of DDT for earworm control.

Treatments	*Percent corn silking at 1st. application*	*Percent worm-free ears*
Stencil Brush: 5 applications of 10% DDT, at 2-day intervals	17	90
	28	90
	64	73
	88	83
Stencil Brush: 5 applications of 1 part 10% DDT with 2 parts cotton seed meal at 2-day intervals	17	93
	38	75
	64	49
	88	68
Sponge: 1 application of 1% DDT in 99% mineral oil	100	97
Untreated	–	3

to keep the water and oil from separating. These treatments were applied only once, 8 days after the first silk had appeared in the field. A plot consisted of a single row of sweet corn 20 feet in length, with each treatment replicated 8 times.

The fourth experiment was conducted to compare the effectiveness of the stencil brush method with that of the sponge method for earworm control. Four applications of 10 per cent DDT dust were applied with the stencil brush at 3-day intervals with the first being made when 16 per cent of the sweet corn plants were silking. A 0.5 per cent DDT-25 per cent mineral-water emulsion, with 1 teaspoon of "Fab" added to each gallon, was sponged on individual silk masses 8 days after the first silk had appeared in the field. A plot consisted of a single row of sweet corn 30 feet in length. Each treatment was replicated four times.

At harvest time 10 or more ears were examined from each plot and the degree of earworm damage and tip injury caused by the oil recorded.

DISCUSSION

The data in Table 1 shows that good earworm control was obtained with the stencil brush method of applying DDT. Four applications, at 3-day intervals, were slightly more effective than three applications at the same time interval. The data in Table 1 shows that an interval of 3 days between applications was the most practical. Addition of cotton seed meal did not increase the effectiveness of the DDT dust. The stencil brush method of DDT dust application was just as effective as sponging a 1 per cent DDT-99 per cent oil solution on the silk masses. The ears in the stencil brush plots were filled with sweet corn kernels all the way up the tip whereas those ears in the plots sponged with the DDT-oil solution had no kernel development on the terminal 2 inches of the ear.

Data secured in Experiment 2 shows that effective earworm control can be obtained when the first stencil brush treatment is applied when 38 per cent of the sweet corn plants have silked. Less effective earworm control resulted when the first stencil brush treatment was delayed until 64 per cent of the sweet corn plants were silking, as may be noted from the data in Table 2. Most effective earworm control was obtained when the first stencil brush treatment was applied when only 17 per cent of the sweet corn plants were showing silks. In this experiment the sponge application of 1 per cent DDT in oil resulted in a slightly better earworm control than where the stencil brush method was used.

In experiment 3 water was substituted for part of the oil in the 1 per cent DDT-99 per cent oil solution. The data in Table 3 shows that economical earworm control was obtained with all formulations used. The data further shows that reducing the oil concentration also reduces the amount of oil injury on the eartips. However, the formulations with water required constant shaking to prevent the water and oil from separating.

As can be seen by the data presented in Table 4 the stencil brush

Table 3. The amount of tip injury to sweet corn ears resulting from the sponge applications of various concentrations of oil in the DDT-oil formulations.

Treatment, Sponge	*Percent Worm-free ears*	*Percent ears with Inches oil injury on ear tip* 0	1.5	1.5+
1% DDT + 99% oil	92	7	18	75
1% DDT + 50% oil + 49% water	93	4	40	27
1% DDT + 25% oil + 74% water	92	26	47	27
Untreated	4	....	....	....

Table 4. A comparison between the earworm control obtained from the stencil.

Treatments	*Percent worm-free ears*
Stencil Brush*	85
Sponge**	97
Untreated	4

* 4 applications of 10% DDT at 2-day intervals
** 1 application of a 0.5% DDT + 25% mineral oil + 74.5% water emulsion

treatments resulted in 85 per cent worm-free ears. Slightly better control was secured with a single application of 0.5 per cent DDT + 25 per cent oil + water, with 1 teaspoon of the detergent "Fab" added to each gallon of emulsion to prevent the oil and water from separating, and oil damage to the ear tips.

SUMMARY

Stencil brush applications of 10 per cent DDT dust applied four times at 3-day intervals resulted in effective earworm control. Most effective earworm control was obtained when the first application was made at the time 38 per cent of the plants were silking.

Sponging a solution of 1 per cent DDT in 99 per cent mineral oil on individual silk masses was slightly more effective than the stencil brush treatment with 10 per cent DDT dust.

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Popcorn — A Potential Cash Crop for the Lower Rio Grande Valley

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Due to the recent decrease in cotton acreage allotments, farmers are searching for new cash crops to replace the cotton which was taken out of production. An experiment on popcorn varieties and hybrids was conducted at Substation No. 15 to determine the possibilities for popcorn production in the Lower Rio Grande Valley. Notes were also taken on the severity and control of the corn earworm, *Heliothes zea.*

PROCEDURE

Each plot consisted of two 30-foot rows of corn spaced 38 inches apart. Each hybrid was replicated 4 times. The popcorn was planted on February 10, 1955 and harvested on June 15 to 17. Prior to planting, the plots received an application of fertilizer applied at the rate of 40 pounds of nitrogen and 80 pounds of phosphorus per acre. On April 28, nitrogen (Ammonia) was applied in the irrigation water at the rate of 45 pounds per acre. The popcorn planting was spaced at a distance of 9 to 10 inches apart in each row.

On April 2 the first replication was treated for earworm control. The first row of each hybrid plot was treated only once whereas the second row received a second application three days later. Approximately 3 drops

Table 1. Yield and length of popcorn ears grown at Weslaco.

	Bushels shelled grain (15% moisture) with no. earworm treatments			*Percent ears with following length*		
	0	*1*	*2*	*3"*	*3-6"*	*6-9"*
4483-25 x SA44 ***	61.9	65.3	68.8	4.3	31.1	64.4
4483-16-4 x 4482-18 ***	52.6	55.2	56.3	5.7	62.7	31.6
4483-15 x 46204-5 ***	59.9	60.2	61.5	5.7	62.7	31.6
South American Hybrid *	62.5	64.3	65.7	8.7	74.0	17.3
White Hulless Hybrid **	36.7	44.8	34.7	36.5	63.5	0
46203-8 x SA44 ***	63.3	75.2	77.7	5.6	62.3	32.1
4483-15 x SA42-2 ***	48.3	61.6	63.6	5.8	36.0	58.2
White Rice **	31.5	43.6	44.1	23.0	64.3	12.7
White Hulless **	14.3	18.3	18.4	77.5	22.5	0
Hinhybrid 250*	15.4	20.5	20.5	78.5	21.5	0
SG18 x SA44 ***	48.4	54.5	50.3	6.7	63.6	29.7
L.S.D. at: 1% level 3.58						
5% level 2.51						

* Northrup King Co.
** Ferry-Morse Seed Co.
*** Texas Agricultural Experiment Station, experimental hybrids

Table 2. Effectiveness of a 1% DDT-25% oil emulsion earworm treatment on various popcorn hybrids.

	No. of Earworm Treatments	Percent of Ears with the following Inches of Earworm Injury		
		0–0.5	0.5–1.0	1.0 plus
South American Hybrid	0	23.7	35.0	41.3
	1	47.2	27.8	25.0
	2	77.2	11.4	11.4
4483-16-4 x 4482-18	0	29.1	32.5	38.4
	1	72.7	9.1	18.2
	2	77.5	12.5	10.0
4483-15 x 4620-5	0	26.0	38.1	35.9
	1	34.3	41.1	26.4
	2	71.2	18.6	10.2
South American Hybrid	0	23.7	35.0	41.3
	1	68.8	16.7	18.5
	2	56.7	35.0	8.3
White Hulless Hybrid	0	1.9	15.5	82.7
	1	19.7	25.8	55.5
	2	9.8	9.8	80.4
4620-8 x SA44	0	37.0	33.6	29.3
	1	79.1	11.6	9.3
	2	74.1	22.4	3.5
4483-15 x SA 42-2	0	10.3	31.4	58.3
	1	61.0	21.9	17.1
	2	53.2	23.4	23.4
White Rice	0	3.1	8.8	88.1
	1	10.5	10.5	79.0
	2	20.4	12.2	67.4
White Hulless	0	5.7	5.7	88.6
	1	27.3	24.2	48.9
	2	32.4	2.7	64.9
Minhybrid 250	0	8.1	10.8	81.2
	1	48.7	30.8	20.5
	2	36.8	15.9	47.3
SG18 x SA44	0	24.1	32.1	43.8
	1	52.8	35.8	11.4
	2	84.8	7.6	7.6

of a 1% DDT-20% oil-79% water emulsion were applied into the silk channels with an oil can.

At harvest time the popcorn from each plot was harvested, shelled and weights of the popcorn corrected for a moisture content of 15%.

YIELD

The data in Table 1 show a direct correlation between ear length and yields. Hybrids of White Hulless, Minhybrid, and the varieties, White Rice and White Hulless had a high percentage of small ears and low yields, indicating that these varieties can not be grown commercially in this area.

The most promising entries were the three experimental hybrids 46203-8 X SA44, 4483-25 X SA44, and 4483-15 X 46204-5 and the commercial hybrid South American. The data (Table 1) show that these hybrids have a high percentage of large ears and the yields of shelled pepcorn are high enough to justify planting popcorn as a cash crop, at least on a trial basis.

CORN EARWORM CONTROL

The data in Table 1 show that one and two treatment applications of the DDT-mineral oil emulsion increased the yield of shelled popcorn in all the hybrids except 4483-15 X 46204-5. The increase in yields was greatest on hybrids 4483-15 X SA42-2 and 44203-8 X SA44, which were high yielders without earworm damage, indicating that earworm damage is not a seriously limiting factor in the hybrids and varieties showing earworm resistance (Table 2). In Table 2 the data show that corn earworm injury was very severe on the varieties White Rice, White Hulless and the hybrid, Minhybrid. Earworm treatments did not increase yields in sufficient amounts so that these varieties could be grown commercially in this area. These 3 earworm-susceptible popcorn varieties produced small ears indicating that varietal adaptation is more of a factor than earworm damage in the production of popcorn in this area.

The data in Table 1 show that good yields of popcorn were produced without earworm control. A single application of the DDT-mineral oil emulsion cost about $5 per acre and the yield increases on the higher-yielding hybrids justify such an expense.

SUMMARY

The performance of the hybrids 46203-8 X SA44, 4483-25 X SA44, 4483-5-15 X 46204-5 and South American shows that popcorn is a potential cash crop for the Lower Rio Grande Valley.

Earworm control increased yields of the high-yielding hybrids but was not practicable on the low-yielding hybrids.

ORNAMENTAL SECTION

C. S. Waugh—*Section Chairman*

Black Root Rot of Pothos (Ivy)

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Pothos, *Scindapsus aureus*, sometimes called Ivy or Ivy-arum, has suffered extensive losses from a black root rot disease (Figure 1) in recent years in certain Valley ornamental nurseries. The heaviest losses occur during the cool months, November, December, January and February, when the market demands are highest for vegetative ornamental plants like Pothos. Losses of 50 to 75 per cent of the plants are not uncommon. The losses are particularly serious since the root rot condition develops in plants that are ready or nearly so for the retail market. Frequently plants with healthy appearing tops are not salable because of poor roots. Observations and experimental trials have been made over the past 2 years to determine the cause of the malady and how to minimize the losses.

OBSERVATIONS, TRIALS AND RESULTS

The growing of Pothos for production purposes on a large scale, in brief, is as follows: tip cutting are made from stock beds, rooted in green house benches and potted, 3 plants to a 3-inch clay pot, in steam sterilized soil. These are kept in the greenhouse for 2 to 3 months, or until ready for market. A high humid condition is maintained in the greenhouse in part by frequent watering of the potted plants, which keeps the soil moisture high and reduces aeration. Pothos may be classed as a semiaerial plant, which grows naturally in a tropical humid climate and a well drained soil high in organic matter.

In the first test varying amounts of soil sulfur and ammonium phosphate were added to the steam sterilized soil. See Table 1 for specific treatments and results. These amendments were used with the thought in mind that the root rot condition might be minimized by one or more of these treatments. The test ran for 3 months in the greenhouse and received routine greenhouse care. At the end of the test in January none of the treatments were effective in reducing the incidence of root rot below that of the control. The addition of either sulfur or ammonium phosphate or both made the root-rot situation worse, and surprisingly the greatest amount of root-rot was in the ammonium phosphate treatments.

During the course of the trial with soil amendments it was noted that where aerial roots developed and extended into the wood shavings packed around the potted ivy on the greenhouse benches that healthy roots developed, even though the plant roots in the pot were badly rotted. This observation gave rise to a preliminary test, Table 2, in which wood shavings were used. The results were very interesting. There was a 50 per cent increase in marketable 3-plant pots for the wood shavings medium over the control in which steam sterilized potting soil was used.

Table 1. Effect of soil amendments in steam sterilized soil on incidence of rootrot in Pothos, 3 months after potting.

Treatments	*3-plant pots star of test*	*Condition of plants after 3 months in greenhouse* — *Marketable 3-plant pots*	*Total plants, good tops and roots in all pots*
	Number	*Percent*	*Percent*
Check, potting soil	242	47.4	63.4
Potting soil plus yeast culture	123	39.8	56.4
Ammo-phos 16-20 8 g./cu.ft.	118	38.9	52.5
Soil sulfur 14 g./cu.ft.	133	36.8	55.1
Soil sulfur 113 g./cu.ft.	118	33.1	49.7
2-year old potting soil plus sulfur	97	27.8	40.2
Soil sulfur 28 g./cu. ft.	118	27.1	45.2
Soil sulfur 56 g./cu.ft.	119	26.9	45.7
Soil used once	115	26.1	41.5
Ammo-phos 16-20 24 g./cu.ft.	110	25.5	43.3
Potting soil 9 parts			
Soil used once 1 part	122	24.6	41.8
Ammo-phos 16-20 16 g./cu.ft.	115	21.7	40.0
Ammo-phos 16-20 56 g./cu.ft.			
Sulfur 16 g.	120	21.7	41.9
Ammo-phos 16-20 56 g./cu.ft.			
16 g. in			
9 to 1 parts potting and used soil	119	17.7	32.7

Note: Plants potted October 8, 1955
Last column includes all plants with good tops and roots, regardless of number of plants in a pot when test was terminated.

Table 2. A preliminary trial on the use of wood shavings to control root rot in Pothos.

Treatment (*20 3-plant pots in each treatment*)	*Condition of plants after 3 months in greenhouse* — *Marketable 3-plant pots*	*3-plant pots with good roots*
	Percent	*Percent*
Clean wood shavings	95	95
Mixture 1 part clean shavings and 3 parts potting soil	80	80
Wood shavings partly decomposed from greenhouse benches	80	85
Mixture 1 part clean shavings and 1 part potting soil	65	65
Regular potting soil, control	60	75
Clean wood shavings, 1 inch layer bottom of pot, rest potting soil	50	80

Note: Pothos potted up January 7, 1956, observed April 9, 1956.

Table 3. Effect of potting materials and combinations on root rot of Pothos.

Treatment	*3-plant pots start of test*	*Condition of plants after 3.5 months in greenhouse* — *Marketable 3-plant pots*	*3-plant pots with good roots*
	Number	*Percent*	*Percent*
Gin trash	41	78.0	85.3
Shavings	45	73.3	79.9
Shavings & Nitro sol	45	64.4	86.6
Top soil 50%,Leaf Mold 50%	45	62.2	64.4
Shavings-Leaf mold	45	62.2	71.0
Peat-potting soil	46	58.6	58.6
Leaf mold	45	55.5	59.9
Sawdust, gum	47	55.3	59.5
Shavings-Gin trash	45	48.8	75.4
Shavings-Potting soil	45	48.8	66.5
Leaf mold	45	48.8	57.6
Peat-Gin trash	47	42.5	51.0
Potting soil, control	90	40.0	45.5
Sawdust 75%, potting soil 25%	42	38.1	45.2
Leaf mold-Potting soil	46	37.4	41.2
Shavings-Peat	46	32.6	41.2
Peat-Leaf mold	45	31.1	33.3
Gin trash-Potting soil	45	28.8	42.1
Sawdust 25%, Potting soil 75%	44	27.2	38.5
Sawdust 50%, Potting soil 50%	45	26.6	28.8
Peat	45	17.7	17.7

Note: Potted 3 plants to a 3-inch clay pot, September 26, 1956.
Observations on root condition taken January 14, 1957
In mixtures as Shavings and Leaf mold 50% of each used.
To be classed as marketable plants, both the roots and tops had to be in good condition.

Even, partly decomposed unsterilized wood shavings reduced the incidence of root rot.

A rather comprehensive trial was set up in the fall of 1956 using wood shavings, gin trash, leaf mold, peat and regular sterilized potting soil, alone and in various combinations. See Table 3 for treatments and results. Of the various mediums used gin trash and wood shavings were the most effective in reducing root rot and gave the highest percentage of marketable plants. The increase in marketable plants, plants with good roots and tops, was 90 per cent for the gin trash and 80 per cent of the wood shavings. Ten other treatments were less effective than these two, but better than the control—the regular steam sterilized potting soil.

Observations made during the period the trials were being conducted consistently indicated that excessive soil moisture was probably the

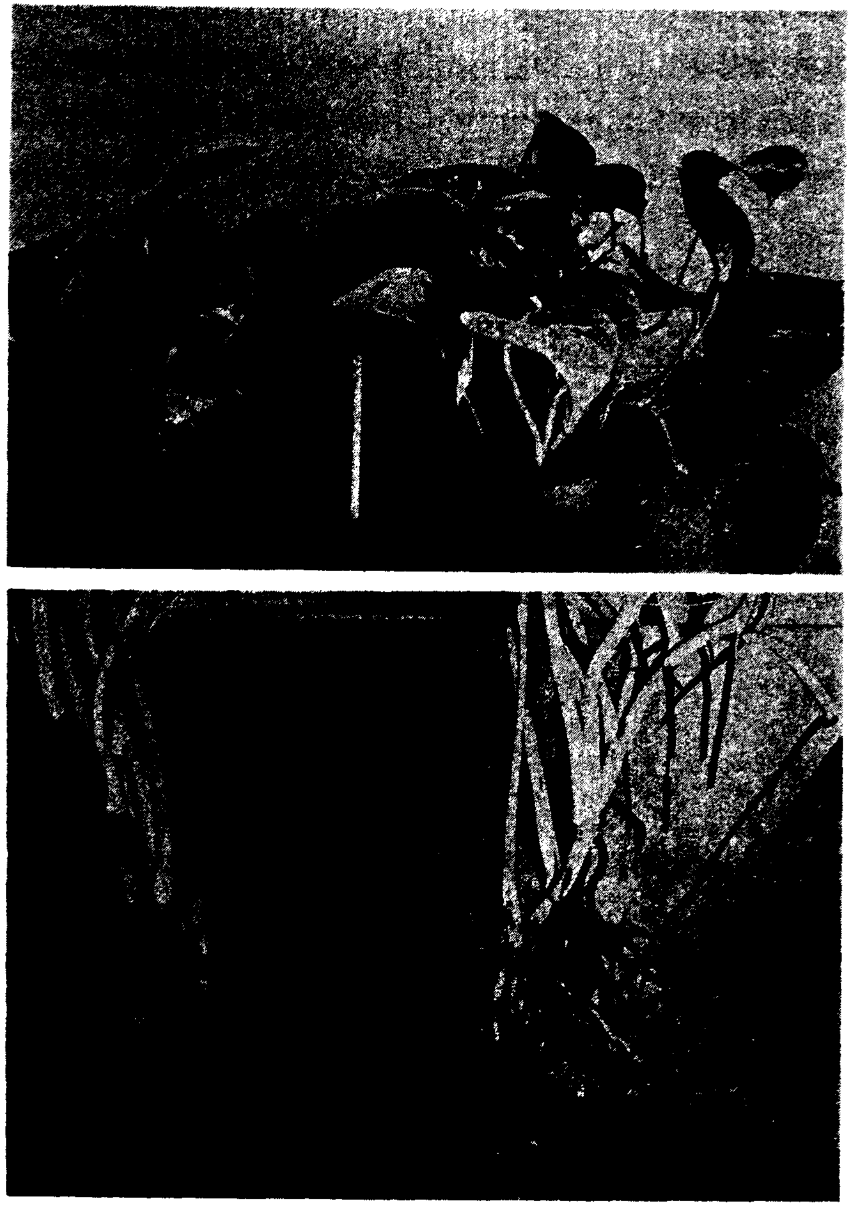

Figure 1. Two Pothos plants, same age, growing in 3-inch clay pots. Plant on the left affected with black-root-rot and healthy plant on the right. Upper figure shows top condition and lower figure the root condition of the two plants. Functioning roots are practically absent in plant on the left.

primary factor causing the black root rot condition of Pothos. Less root rot was found in potted plants that were located along the edges of the benches where excessive water drained off readily. The excellent results obtained with the use of gin trash and wood shavings is explained in part by good aeration and drainage, which these coarse materials provided. Under greenhouse conditions the structure of the regular potting soil, tends to break down and become more or less waterlogged.

The case for pathogenic fungi is believed to be associated with the excessive soil moisture condition. Fungi such as *Pythium* which were isolated in several instances, thrive under excessive moist soil conditions. Nematodes are not considered to be a factor, even though they have been suspected. Several examinations have been made and no parasitic nematodes have been found.

CONCLUSIONS

On the basis of data obtained and observations made it is apparent that certain things can be done that will help reduce the losses caused by black root rot. The present practice of sterilizing the soil with live steam is a good practice, but it is evident that this is not the answer to the present problem. It is suggested that the present practice of sterilizing the soil be continued but with some changes in greenhouse practices. The important change to make is to improve soil moisture drainage and aeration in the pots. This might be done by (1) providing for better bench drainage and aeration, and (2) by incorporating some material as wood shavings, gin trash, or sand in present potting medium. The amount of such material to add to give best results would have to be determined by some preliminary trials. If both methods were combined, there is reason to think that the Pothos root rot trouble would soon be a minor one.

A second approach to the black root rot problem and one that has considerable promise is that of changing to a growing medium of shavings or gin trash. Also, it is not unlikely that sawdust could be used to an advantage. The use of such materials have some drawbacks in the way of preparing for market and acceptance by the retail purchaser.

The problem of growing Pothos for the green foliage trade is complicated by the normal needs of the plant, which requires a humid atmosphere for the foliage growth and a well drained and aerated soil for the roots. The usual greenhouse watering practice is to apply lots of water to the plants so as to keep a humid atmosphere, but in the process an excess of water is put into the soil which in turn brings about an oxygen starvation of the roots. It is believed that losses can be substantially reduced by modifying present practices along the lines suggested.

Ornamental Plants for the Rio Grande Valley of Texas

C. S. WAUGH, *McAllen*

The following is only a partial list of the many plants that will grow well in the Rio Grande Valley of Texas, but these are considered among the best. Many other plants can be grown here with a little extra care, but for general plantings these yield more pleasure with a smaller amount of work.

TREES

AFRICAN TULIP TREE *(Spathodea campanulata)*—A handsome tall evergreen tree native to tropical Africa. It is being increasingly used in California where it sometimes becomes deciduous under their conditions. Young trees of this variety are doing well in the Rio Grande Valley but none are old enough here to produce the tulip-like orange-red blossoms which appear in the winter.

ORCHID TREE *(Bauhinia)*—There are several varieties of this family, the most widely used of which is the Bauhinia Purpurea which has large clusters of blossoms ranging in color from white to purple. Bauhinia Galpini is a vine-like shrub producing clusters of red blossoms. A new variety, the Hong Kong Orchid tree is beginning to be grown in this section. Its blossoms are larger and darker than the other varieties. The tree sheds its leaves during the winter, and the blossoms appear before the new leaves, causing them to be quite spectacular.

ROYAL POINCIANA *(Delonix regia)*—This is one of the most spectacular blooming trees grown in the Rio Grande Valley of Texas. The flaming orange-red clusters of blossoms appear on the mature trees in May or June and generally remain until August or September. It is called by the Spanish-speaking people "Flambouyant" and lives up to its name. It is very fast growing and makes a good umbrella-shaped shade tree with lacy foliage which it usually sheds in the winter.

VINES

ALLAMANDA (al. *Cathartica)*—A medium fast-growing plant with dark green leaves that has a tendency to grow into a vine but may be made into a bush by pruning and staking. The variety hendersoni has large flaring trumpet-shaped blossoms of gold. Cryptostegia is sometimes called purple Allamanda because it has a blossom and growth similar to the true allamanda but has purple blossoms.

BOUGAINVILLEA—A fast-growing vine which can be used as a shrub if pruned back occasionally. The most prolific blooming variety is Barbara Karst which is the most widely used. It is a bright fushia-red. The second most popular variety is the large-blooming purple-flowered Convent. It does not grow as fast nor as large as the Barbara Karst. Newer varieties include the tangerine-colored Afterglow, the golden-

yellow called Golden Dawn, the orchid-pink called Texas Dawn, the Rose-colored called Rose Queen, the White called Purity, and the new dwarf variety with the red blossom called Temple Fire. The Bougainvillea seems to be ideally suited to the Rio Grande Valley conditions as it likes hot weather and does not require much water. It is tolerant to alkaline soils but grows faster and blooms more profusely when fed frequently with an acid plant food containing iron.

CREEPING FIG *(Ficus pumila)*—A hardy tenacious evergreen climber with very small leaves which will cling to wooden or masonry surfaces. Requires good drainage.

SHRUBS

ACALYPHA *(Copper plant)*—A fast growing colored foliage plant with a combination of red, green, yellow and pink attractively arranged in the leaves. Grows fairly large and is hardy under normal conditions, although it may freeze to the ground during severe winters. When it does freeze it usually sprouts rapidly.

BARBADOS CHERRY *(Malpighia coccigera)*—This is an ornamental shrub of fine texture with attractive rose-colored blossoms and three-lobed cherry-like fruits which are edible. It is fast growing.

BRAZILIAN PEPPER *(Schinus terebinthifolius)*—This plant is most widely used for tall screens and wind-breaks. It may be pruned into a tree if desired. It is a fine-foliaged evergreen, and has attractive red fruit which, when crushed, has an odor similar to black pepper. It is very fast growing.

CARRISA *(Natal plum)*—This is a compact-growing, thorny shrub which is evergreen with fragrant white star-shaped blossoms sometimes followed by red plum-like fruits which can be eaten fresh but are more used in making jelly and preserves. The leathery foliage is a bright green and the plant can be pruned to the size or shape desired. It is seldom bothered by any kind of pest.

CROTON *(Codiaeum variegatum)*—One of the most widely used colored foliage plants coming in an endless variety of color combinations and leaf shapes. In the Valley they seem to do better in partial shade. Young plants should be dusted or sprayed to control red spider which sometimes causes the leaves to drop and even in extreme cases kills the plants.

ESPERANZA *(Coma stans)*—In Florida this plant is called Yellow Elder. It has bell-shaped golden yellow blossoms which on the better varieties almost conceal the foliage. It will stand alkaline conditions and drought very well. It is sometimes used for screening purposes.

FIRETHORN *(Pyracantha spp)*—This is a large-growing shrub or small tree which bears quantities of red or orange berries which are usually ripe at Christmas and during the winter season. It is sometimes attacked by fireblight which may be controlled by use of copper fungicide. The foliage is sometimes mutilated by tne lace bug or leaf tier which can usually be controlled by frequetn applications of DDT or Lindane. It will do much better if mulched regularly.

GARDENIA *(G. jasminoides)*—A sweet-scented white blossom appearing against the rich dark green foliage makes this one of the most popular plants. There are many varieties but the G. Mystery seems to thrive best in this area. The Gardenia should be planted so that it has good drainage and a quantity of peat moss should be incorporated in the soil around the plant. A mulch of well rotted barnyard manure over the top of the soil helps to keep the moisture even. It needs an acid fertilizer with iron and zinc added for best growth and bloom. It does best on the East or North side of the house or where it gets partial shade. The Gardenia is sometimes attacked by nematodes which can be controlled with a soil fumigant.

HIBISCUS *(H. rosea sinensis)* — Sometimes called the Queen of Shrubs. There are hundreds of varieties being successfully grown in the Rio Grande Valley. The colors range from pure white to yellow through all the shades of pink and into an almost black-red. They grow quickly and give a large amount of bloom with very little care, and seem to respond well to an acid fertilizer with iron manganese and zinc. One of the most widely used plants in the Valley is the Hibiscus, with blossoms either single, double or semi-double, and varying in size from two or three inches across to the size of a dinner plate.

IXORA *(Flame of the Woods)*—The most widely grown variety is coccinea which has showey clusters of tubular-shaped flowers of a vivid red color. Newer varieties include the Superking which has larger foliage with large, heavy blossoms and seems more resistant to alkaline conditions. There are also ivory and pink varieties now available. The Ixora does best if planted on the east or north side and kept heavily mulched with peat moss or ebony leaf mold. It requires acid fertilizer with plenty of iron added.

LANTANA—Some form of Lantana are native to the Valley and grow wild here. The newer dwarf forms come in pink and pure yellow. They are very hardy and bloom freely. The Trailing Lantana makes a fine ground cover for borders or other dry and different places. This variety has a lavender blossom and never grows more than about 12 inches tall.

OLEANDER *(Nerium)*—This is a fast growing shrub, blooming prolificly and is much used for screening alleys and other undesirable views. The colors range from white through various shades of pink to a full rich red, in both double, semi-double and single blossoms. The Sealey Pink Oleander is probably the most widely used variety because it blooms over a longer period of time and has a tendency to branch nearer the ground.

ORANGE JESSAMINE *(Murraya exotica)*—This shrub has small inconspicuous white blossoms with the fragrance of orange blossoms. The

plants grow tall with shiny green foliage. It may be clipped and shaped to any desired height from about 18 inches to 5 or 6 feet.

PENTAS—This plant is named for its five-pointed blossoms in clusters in red, several shades of pink, white or lavender. The blossoms are often used for cut flowers, and the plant is usually covered with a profusion of blossoms. It needs good drainage and should not be overwatered. It will grow in full sun, but is more satisfactory in part-shade. It usually grows to a height of about 24 inches with a similar spread, and is used to best advantage as a bank or border against a wall.

PITTOSPORUM *(P. tobira)*—This shrub has fairly large elliptical foliage borne in a circular pattern. The foliage is much used for cutting and combining with flower arrangements. It is quite hardy, but is rather slow-growing. A variegated form is also grown. The Pittosporum is sometimes attacked by the white fly and cottony cushion scale, both of which may be controlled with a Malathion spray.

POINSETTIA *(Euphorbia pulcherima)*—This is a very fast growing plant which is much admired when it blooms during the winter months. The foliage and plant are sometimes straggly in appearance. The plants should be pruned in early February and again in early August to make strong canes and large blossoms at Christmas. The double red variety, Henrietta Ecke, is most widely used, although the white and pink are gaining in popularity. The plants hold their foliage better if a quantity of peat moss is worked into the soil and the plants are kept evenly watered with frequent light feedings.

GARDENING HINTS

The soil and water in the Rio Grande Valley of Texas are normally slightly alkaline and range to very alkaline when water is scarce. These akalies act as a binder to make the soil formation tight so that moisture and food do not penetrate to the roots quickly and the roots in turn do not spread as they should. Any kind of vegetative material such as compost, leaf mold, peat moss, barnyard manure and grass clippings will help to treat the porosity of the soil and with the addition of nitrogen fertilizers with an acid base most plants grow very rapidly and thrive well. A number of the mineral elements, especially iron and zinc, combine rapidly with the alkali and in such combinations cannot be used by the plants. Soil sulphur, gysum, sulphur-based fertilizers and other acid-forming chemicals help to reduce the alkalinity and prevent chlorosis (leaf-yelowing). Iron chelate and iron sulphate are the two best iron compounds with zinc sulphate the best zinc additive. These elements may be obtained in commercial fertilizers and mixtures from the various nurseries. As there is no true rest period in the Rio Grande Valley, plants should be fertilized once each month except during December and January when we normally have our coldest weather. Most plants require some pruning, but pruning should be done fairly frequently to shape the plant. Any heavy pruning should be done in early spring. All plants seem to respond to having the soil about the roots covered with some form of mulch such as well-rotted cow manure or peat moss during the hot summer months. This helps to retain the moisture and prevents the heat from reaching the root zone and decreases the alkali build-up.

Frequent dustings or sprayings should be made to prevent insect and disease infestations on the plants, particularly during the seasons when the nights are damp and the foliage is kept wet with the dew.

The proper use of one or a number of the above-listed plants can give many days of pleasure to the gardener which will more than reimburse him for the work done to produce them.

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