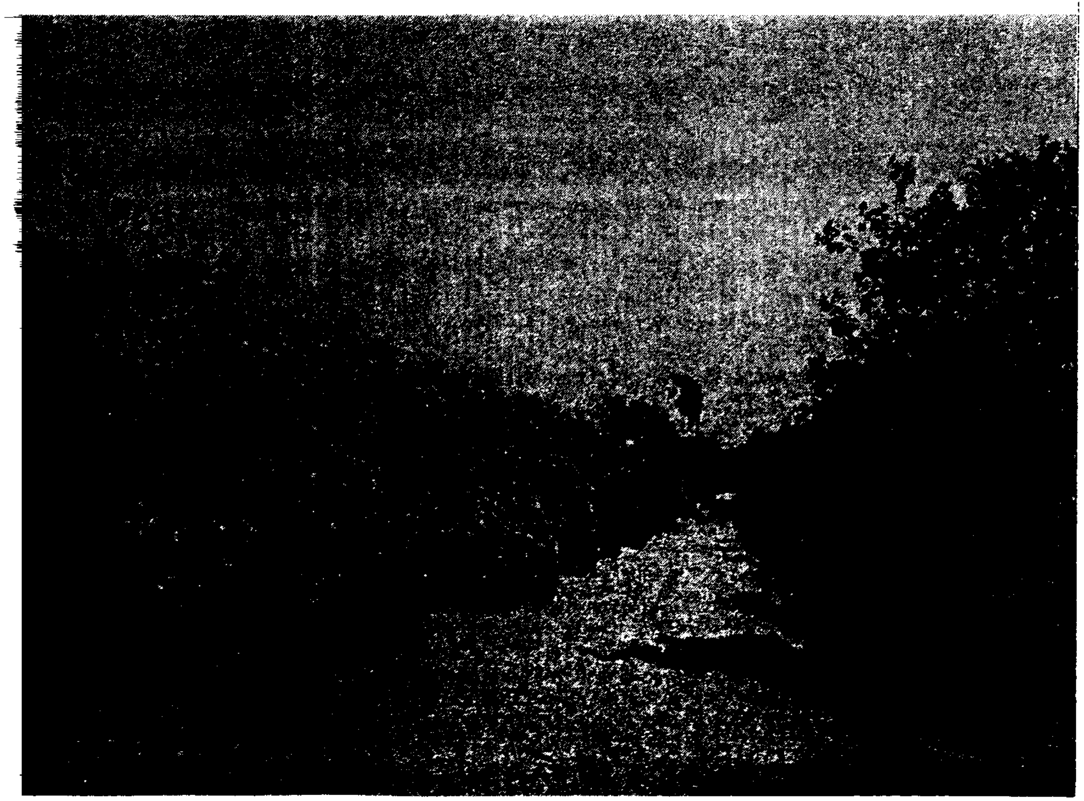
JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 12, 1958



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RIO GRANDE VALLEY HORTICULTURAL SOCIETY
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Editor, Edward O. Olson

Associate Editor, Bailey Sleeth

Aims and Objectives of the Society

The Rio Grande Valley Horticultural Society represents an amalgamation of the former Valley Horticultural Club, the Texas Avocado Society, and the Valley Grape Association.

The purpose of the Rio Grande Valley Horticultural Society is the advancement and development of horticulture in the Lower Rio Grande Valley. It is the aim of the Society to stimulate interest in research and its practical application to Valley problems with fruit, vegetables and ornamentals.

At monthly meetings subjects of interest are presented by specialists in their fields. These presentations are followed by open forums. The Newsletter announces and discusses the monthly programs and brings other news of interest to Society members.

The Society has sponsored 12 annual Institutes, where outstanding speakers from all parts of the country present new developments in the field of horticulture. Panel discussions, social get-togethers and a barbecue round up the all-day program.

Talks given at the Institute and reports of Valley research are published in the Journal of the Society, which provides a continuing record of horticultural progress in the Valley.

Anyone interested in horticulture can become a member of the Society. The annual fee is $4.00, which includes the Journal. Applications for membership, and annual dues should be sent to the Secretary-Treasurer, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas.

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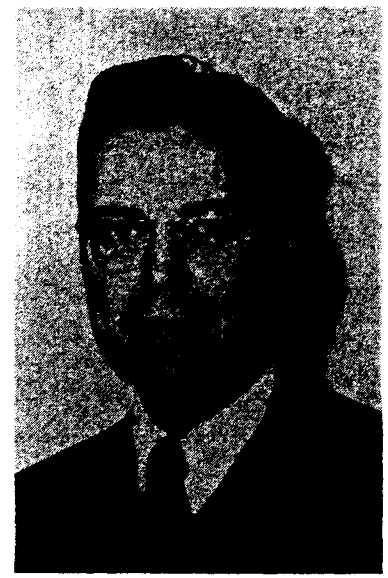

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Cover Picture—A common Valley scene, with red grapefruit trees in the foreground and palm trees in the distance.

The Arthur T. Potts Award

Given for meritorious service in behalf of horticulture in the Lower Rio Grande Valley. Recipients of this award include:

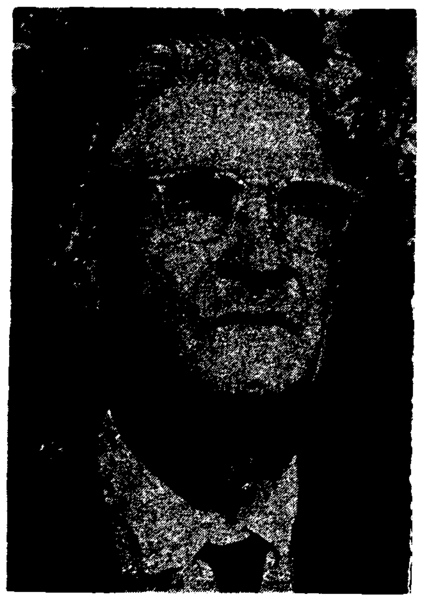
Arthur T. Potts	(1955)
Dr. Wilson Popenoe	(1956)
E. M. Goodwin	(1957)
Dr. J. B. Webb	(1958)

Dr. J. B. Webb, shown by his discovery, the original Webb Red Blush grapefruit tree.

Dr. J. B. Webb
Recipient of the Arthur T. Potts Award
January 21, 1958

Nothing has had greater impact on the Lower Rio Grande Valley citrus industry than the discovery of the strains of red-meated seedless grapefruit.

This year's Arthur T. Potts Award goes to Dr. J. B. Webb, the Donna physician, whose discovery was an entire tree bearing red-fleshed seedless grapefruit showing a beautiful blush on the outside. Most red-meated types have been found as bud sports on single limbs or branches.



Dr. Webb budded a number of trees from a Marsh Pink seedless grapefruit in 1929. In 1930, the trees froze down to the banks. On one of these trees he selected the most likely looking shoot to tie up, using the frozen top as a stake, to produce a new top.

In about 1932, Dr. Webb was walking through his young orchard and the trees had a few fruits here and there. One tree stood out because it was so prolific. The fruit looked attractive and had a red blush on the outside so he thought it was a Foster Pink, a seeded red fruit. He cut it and to his surprise the flesh was a deep red and the fruit was seedless.

Dr. Webb believes that the mutation from the Marsh Pink Seedless had been caused by shock of the freeze and it was perhaps by chance that he selected the proper shoot to produce a new tree.

The original tree has never shown any signs of psorosis but is in rather bad shape from the weather, being located in a rather exposed location. It still stands, however, a living monument to a new variety which has become a symbol of Texas grapefruit excellence.

Program of the Twelfth Annual Institute of the Rio Grande Valley Horticultural Society
January 21, 1958

MORNING PROGRAM

INSTITUTE CHAIRMAN .... Dr. J. B. Corns
Horticulturist, Pan American College, Edinburg, Texas

FIRST SESSION

CHAIRMAN .... Dr. John Howe
Director, Division of Agriculture, Texas A. & I. College, Kingsville

Address of Welcome .... Harry Foehner
President, Rio Grande Valley Horticultural Society, and
Editor, Texas Farming and Citriculture, Harlingen

Cantaloupe and Cucumber Research in the Valley .... R. T. Correa
Horticulturist, Texas Agricultural Experiment Station, Weslaco

The Future of Food Preservation .... Dr. E. E. Burns
Horticulturist, Texas Agricultural Experiment Station, College Station

SECOND SESSION

CHAIRMAN .... M. W. Held
Chairman, Citrus Advisory Council, Mission

Virus Diseases of Avocados and Citrus .... Dr. J. M. Wallace
Pathologist, Citrus Experiment Station, Riverside, California

Nucellar Embryony in Citrus .... Dr. William C. Cooper
Physiologist, United States Department of Agriculture, Weslaco

Fertilizing Citrus in Sod Culture .... Norman P. Maxwell
Horticulturist, Texas Agricultural Experiment Station, Weslaco

NOON—BARBECUE

AFTERNOON PROGRAM

THIRD SESSION

CHAIRMAN .... Herbert A. Dean
Entomologist, Texas Agricultural Experiment Station, Weslaco

Arthur T. Potts Award Presentation .... Harry Foehner
President, Rio Grande Valley Horticultural Society, and
Editor, Texas Farming and Citriculture, Harlingen

Production of Clean Citrus Fruit .... Fran E. Fisher
Pathologist, Citrus Experiment Station, Lake Alfred, Florida

Some New Pesticide Developments .... Harry West
Assistant Research Director, Niagara Chemical Company,
Middleport, N. Y.

FOURTH SESSION

CHAIRMAN .... Dr. Guy W. Adriance
Head, Department of Horticulture, Texas A. & M. College,
College Station

A Bioclimatic Cabinet Study of the Effect of Climate
on Fruit Fly Development and Distribution .... Dr. Norman Flitters
Entomologist, United States Department of Agriculture, Brownsville

Uses of Gibberellic Acid .... Dr. Samuel Johnson
Physiologist, Texas Agricultural Experiment Station, College Station

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CITRUS SECTION

Use of Zineb in Florida Citrus Groves for Controlling Russet and Greasy Spot

FRAN. E. FISHER
Citrus Experiment Station, Lake Alfred, Florida

During the 1956 season, it was found experimentally that 1 lb. of zineb in 100 gallons of water applied once in early or mid-July controlled russet in Florida (Fisher, 1957). Zineb was found to control not only citrus russet but also greasy spot, and depressed rust mite populations for more than six months. Many growers who saw the experimental plots were so enthusiastic about the results that they could not be restrained from using zineb on a commercial basis in 1957. Again, in 1957, the results were spectacular. It has been estimated that commercial use of zineb in the summer of 1957 brought about savings to the growers greater than the entire biennial appropriation for the Florida Citrus Experiment Station (Miller, 1957).

The Florida citrus grower has, for years, faced a serious problem in growing russet-free fruit. The russeting has generally been attributed to activity of the rust mite, *Phyllocoptruta oleivora*, and the only known means of control has been the application of sulfur sprays or dusts several times a year. Sulfur applications gave only short periods of control, and had several other unfortunate effects. Sulfur tended to decrease the soil pH thus increasing the amount of lime required to correct the soil acidity. It killed fungus enemies of harmful insects and mites, thereby permitting these pests to flourish, oftentimes with disastrous results. Finally, it tended to burn the fruit, especially when there was an oil residue from a summer oil spray used to control scale; because of this burning, use of sulfur has frequently been postponed at a season of the year when danger of russeting is great, and the incidence of russet has thereby increased. Zineb has been an especially good material because it has resulted in long periods of control and can safely be mixed with oil emulsion and applied at a time when control of scale, russet, and greasy spot is almost imperative.

It is my purpose here to review the research that led to the use of zineb as a control for russeting and greasy spot and to discuss briefly the effectiveness of this material in relation to the prevailing opinion that russet is caused by the rust mite.

Russet is an external blemish of citrus fruits that generally appears after fruits are almost full size. Injured areas range in color from bronze through shades of brown to black. Various types of russet are given colloquial names. A slight russeting of oranges is called "golden." In the most severe form, "black russet," the surface layers tend to become thickened and ultimately develop a "mud-cake" appearance resembling mud-cake melanose (due to *Diaporthe citri* Fawc.). Another form, also similar to melanose, is referred to as "tear-stain."

Greasy spot affects chiefly the leaves of citrus, but may be also found on small twigs and branches. It has a dark, slightly raised appearance, suggestive of a globule of dark grease under a semi-transparent epidermis. It occurs as more or less circular or somewhat irregular areas on both surfaces of the leaf, but more prominently on the lower. These spots vary in color and pass through a transition from light yellow or mere translucence of the tissues through various shades of brown to very deep brown or black. In the early stages of development, leaves are conspicuously yellow when viewed from the upper surface.

In 1953 and 1954 tests were conducted to learn 1) whether or not it would be possible to reduce the number of applications of sulfur, thereby reducing some of the harmful effects of repeated applications of sulfur, and still obtain satisfactory control of russet, and 2) whether some materials might give control of both russet and greasy spot. The results suggested that repeated applications of several materials would result in bright fruit, and also give control of greasy spot.

More detailed tests were carried out in 1955. Use was made of several materials that had shown promise in the earlier tests. Zineb, captan, silver salicylate, and ziram were chosen to be compared with chemical standards such as basic copper, oil emulsion, parathion-sulfur, and lime-sulfur plus wettable sulfur. The results were striking.

Pineapple oranges that had received only a single spray of zineb at the end of July 1955 were 95 per cent bright when examined the following winter. Results on Valencias were almost as good, the fruit being 90 per cent bright even though only a single zineb spray was applied early in August. Trees sprayed on the same dates with a combination of wettable sulfur and lime-sulfur yielded 85 per cent bright Pineapples and 20 to 50 per cent bright Valencias. Strangely enough 1.3 per cent oil emulsion sprays yielded brighter Valencia and Pineapple fruit than did sulfur. In contrast, fruit that did not receive a summer spray was only 20 per cent bright.

Results in the 1955 season had been invariably good, but it was deemed necessary to carry out additional tests in 1956 for confirmation. It was also desirable to determine the proper dosage of zineb to obtain adequate control. Furthermore, information was also needed on the advisability of combining zineb with oil and parathion.

Zineb at the rate of 1, 1½, or 2 pounds in 100 gallons applied only once, between July 2 and August 3, 1956, controlled russet and greasy spot on every variety tested.

The value of zineb in reducing russet is shown by packinghouse records made at the end of October and into November. Duncan grapefruit treated July 17 with zineb yielded 99 per cent bright fruit, but non-sprayed trees produced only 1.5 per cent. Ruby Red grapefruit sprayed

July 16 had 99 per cent bright fruit, compared to 16 per cent on non-sprayed trees. In the case of Hamlins, all fruit graded 100 per cent bright following zineb applied July 16. Eighty per cent were bright on non-sprayed trees. The fruit remaining on the trees showed no further development of russet up to February 1, 1957. Zineb combined with oil-parathion gave similar results in controlling russet and caused no burn to fruit. This was especially important since it demonstrated that zineb could be applied in a combination spray to control both scale insects and russet at the same time.

Tests with zineb in 1957 were concerned primarily with dosage rates and the combination of zineb with oil emulsion. Many newer organic fungicides were screened together with some of the previously screened but rejected materials. Although harvesting of fruit has not been completed and the maximum greasy spot development will not occur until about February, a few generalized field observations can be made at this time.

Zineb applied at the rate of 1 lb. per 100 gal. gave somewhat more effective russet control than did ½ lb. However, ½ lb. applications resulted in more than 90 per cent bright Homosassa oranges. This is in contrast to poor results obtained in 1956 with ½ lb. Observations also indicate that greasy spot control was more effective with 1 lb. than with ½ lb. when applied alone. In the case of zineb-oil mixtures, it should be pointed out that oil sprays, properly timed, have been effective in controlling greasy spot so that no differences have yet been detected between treatments containing full strength oil and various rates of zineb.

Of the other materials tested for russet control, maneb showed considerable promise; however, maneb in combination with oil emulsion sprays applied in late June or July was found to cause a severe burn on grapefruit. Valencia oranges were not severely injured. Although the summer application of maneb-oil resulted in injury to grapefruit, maneb applied alone or in combination with materials other than oil may be practicable eventually. At this time, however, maneb can not be recommended for use on citrus for several reasons: 1) the fact that no tolerance has yet been set for citrus by the U. S. Food and Drug Administration, 2) the high cost of the material, and 3) the better and less expensive control of greasy spot that can be obtained with zineb, copper, or oil emulsion.

Time of application for greasy spot control and russet control is very important. Although greasy spot infection becomes evident during the fall, control measures should be applied between the middle of June and the first part of August.

Sprays for russet control must also be applied before russeting appears. Thorough coverage is essential for maximum control of both russet and greasy spot. In Florida we do not recommend that growers substitute zineb for sulfur in all cases. Rather, it is recommended that sulfur or zineb be applied as a post-bloom spray and that zineb be used in combination with the summer scalecide.

Although russet has been attributed to many factors, it has commonly been considered to be the result of the feeding of the citrus rust mite. However, it should be pointed out that russet has never been reproduced under controlled conditions in the laboratory. Field observations have shown that the number of rust mites is not always correlated with the amount of russeted fruit. In fact, russet has been known to develop in the absence of rust mites and, conversely, fruit does not always russet in their presence. Nevertheless, it is strongly recommended that rust mites should be controlled in so far as possible whenever sufficient numbers are present to warrant spraying. Even though evidence now indicates that a fungus may be involved, it would appear that more critical work will be necessary to determine the true cause or causes of the blemish.

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Miller, R. L. 1957. Zineb-improved summer control of citrus fruit russet. Citrus Industry 38: 7-9, 27, 28.

Effect of Temperature and Humidity on Development and Distribution of Hawaiian and Mexican Fruit Flies

N. E. Flitters,
Entomology Research Division, Agr. Res. Serv., U.S.D.A., and
P. S. Messenger,
University of California

The primary purpose of the bioclimatic cabinet operation (Figures 1 and 2) has been to study the effect of stimulated conditions of temperature, humidity, and light upon various species of fruit flies considered to be potentially dangerous to agriculture in the United States. Three species were studied in Hawaii—the oriental fruit fly (*Dacus dorsalis* Hendel), the melon fly (*Dacus cucurbitae* Coq.), and the Mediterranean fruit fly (*Ceratitis capitata* Wied). The Mexican fruit fly (*Anastrepha ludens* Loew.) has been studied at Brownsville, Texas. Information on the ability of these insects to reproduce and complete their developmental cycles in climates representative of fruit and vegetable areas of the continental United States, and develop to pest levels, will have much usefulness in regulatory, control, and eradication programs. Assurance that they will probably not ever become a serious problem will have much intangible value to fruit and vegetable growers and pest-control agencies in areas not favorable for the fruit flies.

The design of cabinets for determining the effects of climatic factors upon fruit flies was undertaken in 1949. The use of laboratory equipment for this purpose was not a new idea, but the application of industrial equipment to produce the exacting temperature and relative humidity patterns required for such research work was probably without precedent in entomology. The primary novelty of these cabinets is in their ability to simulate temperatures and humidies in smoothly varying patterns, such as the diurnal pattern occurring naturally.

The bioclimatic cabinets both in Hawaii and in Texas have been operated jointly by the U. S. Department of Agriculture and the University of California Agricultural Experiment Station (Flitters *et al.* 1956). They are of the walk-in refrigerator type, with sectional wall construction to facilitate disassembly and transfer from place to place. Each cabinet is lined with stainless steel. It has 36 square feet of working space and is provided with an anteroom to permit entry without influencing the conditions being maintained within. In the wall opposite the door are 15 square feet of multipane glass to provide a clear view of the interior of the cabinet.

Each cabinet is capable of controlling temperatures through a range from -5 to 125° F. plus or minus 1° dry-bulb temperature. Relative humidity can be controlled through a range from 9 to 95 percent, even at

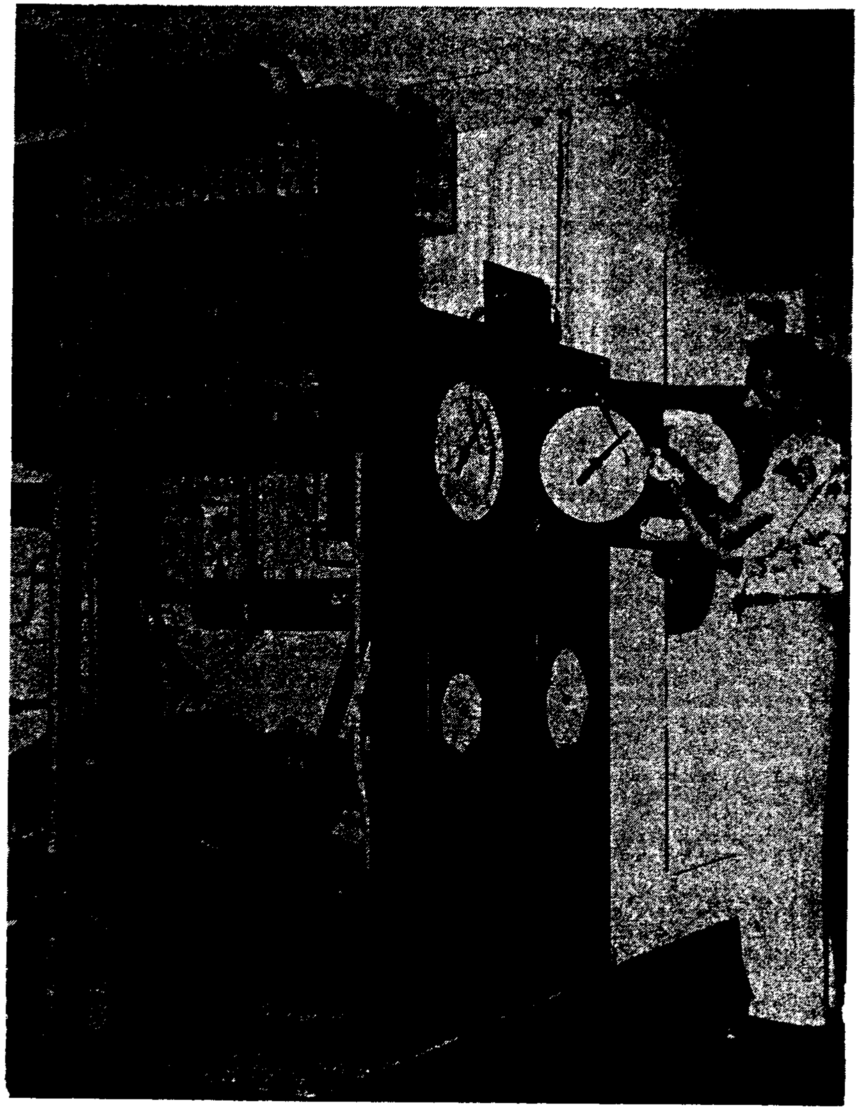

Figure 1. Exterior of bioclimatic cabinet. Transmitting and recording instruments are being examined by the operator; the control mechanisms are housed above the re.rigeration compressor.

subfreezing temperatures in some of the chambers. All cabinets have sufficient capacity to raise or lower the temperature 40° and lower the relative humidity 60 percent in 60 minutes. Fresh air introduced by the circulation system is capable of maintaining a flow of 20 cubic feet per minute.

A lamp designed to give a wide spectral band provides daylight illumination requirements. This is controlled with a time clock regulated to take care of variations in photoperiod caused by changes of the declination of the sun at the sites under study.

Sites considered to represent areas of greatest potential fruit fly hazard in the continental United States, or having characteristics otherwise interesting from the standpoint of possible effect on fruit fly development, were selected for simulation in the cabinets. On the sites selected for study weekly hygrothermograph records were obtained and the data transferred to cams and charts, which control the operation of the cabinets and provide a continuous record of simulation accuracy.

At first temperature and humidity patterns recorded at various locations in the United States were chronologically simulated for the entire year, but recently they have been limited to those periods of the year determined as critical for fruit fly development.

After the conditions of climate for a particular site had been plotted and a study was begun, the cabinet was stocked with fruit flies. Special globular screen cages suspended from a rotating bicycle wheel were used to house these flies, and food in the form of enzymatically hydrolyzed yeast, soy hydrolysate, and sugar, together with water, was provided. In certain cages containing mature fruit flies a substrate, such as papaya or grapefruit, was provided for oviposition.

After a preliminary period in which only the oriental fruit fly was studied, all three species occurring in Hawaii—oriental, melon, and Mediterranean fruit flies—were placed in the same cabinet. Each species was isolated from the others in cages. Adult mortality was determined daily, and equivalent numbers of flies of similar age were introduced to supplant the depleted stocks once weekly.

Fruits exposed and removed from the cages of gravid flies were isolated in special screen containers within the cabinets until preimaginal development of the insect was completed and the adults emerged. The ensuing progeny were collected daily, and members of each generation were confined together, where they were afforded the same diet and their development was determined in the manner prescribed for the parent stocks. Studies were also conducted with newly laid eggs, freshly hatched larvae, newly formed puparia, and freshly emerged adults.

Fruit flies were produced in the insectary with standardized rearing techniques. These techniques included caging and egg-production procedures developed by the U. S. Department of Agriculture, and the special carrot medium for rearing larvae and other manipulations devised by the University of California Agricultural Experiment Station.

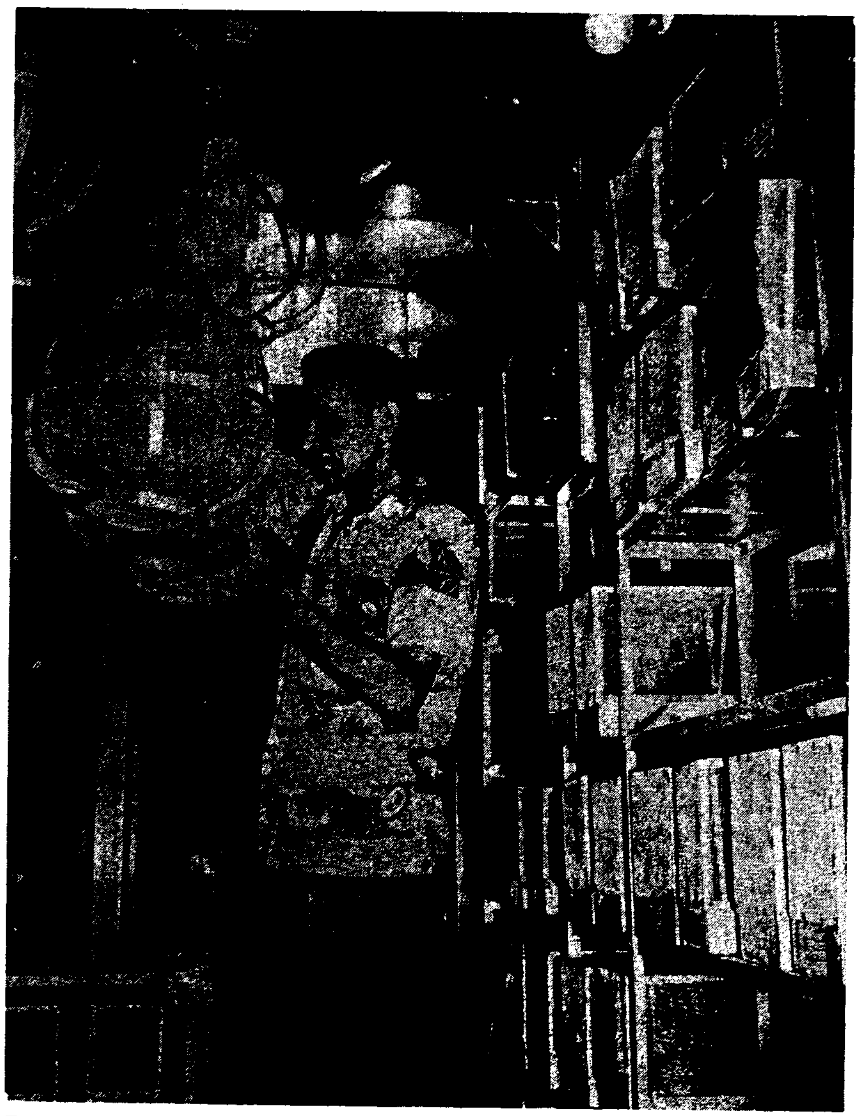

Figure 2. Interior view of bioclimatic cabinet. Globular cages hang suspended from bicycle wheel and fruit isolation cages are contained on the racks on the right.

In Hawaii, simulations of climatic conditions in selected agricultural sites in Florida, Georgia, Louisiana, South Carolina, Texas, Indiana, New Mexico, Arizona, and California, collectively representing almost 25 years of climate, were concluded late in 1954. The results suggest that the mainland areas suitable for these fruit flies are probably considerably less extensive than originally estimated. In most of the California climates simulated, ranging throughout the southern part of the State and as far north as Auburn and Sebastopol, winter conditions inhibited their development and activity. Imperial Valley winters are relatively short, however, and overwintering of the pupal and adult stages of certain of these species may be possible. Excessively hot, dry summers in the Southwest, including the Imperial Valley, inhibit population buildup considerably, and may prevent attainment of pest proportions in these areas.

The data show that the oriental fruit fly may survive winter conditions in those areas of the United States in which there is no more than a 60-day period with average temperatures below 57° F. Such areas include all of Florida south of the 30th parallel, the lower Delta in Louisiana, the lower Rio Grande Valley in Texas, the Imperial Valley of California, and the Yuma and lower Gila River Valleys in Arizona. Those areas having more than 60 days but under 90 days with average temperatures below 57° appear to be marginal for oriental fruit fly production and development, and those with average temperatures below 55° for the Mediterranean fruit fly. Evaluation of similar data on the melon fly is under way. All other areas in the country are capable of supporting infestations of all three species for certain periods of each year, but perpetuation on a self-sustaining basis appears most unlikely. Most of the important fruit and vegetable areas in California are within these unfavorable limits.

When the biological findings in the cabinets were compared with results of outdoor cage studies with the oriental fruit fly conducted by the U. S. Department of Agriculture, they were found to be remarkably similar.

Cabinet studies of the Hawaiian species confirmed findings of previous outdoor cage studies (conducted by K. L. Maehler, C. L. Davis and associates on the islands of Maui and Hawaii), at various elevations in the Hawaiian Islands, which showed that the melon fly has greater tolerance to cool conditions than either of the other species. It may therefore be a greater hazard to agriculture in the continental U.S.A.

The study with the Mediterranean fruit fly in a cabinet simulating Florida conditions showed that the temperatures in the winter of 1929-30 probably did not aid the eradication program in this State at that time. Instead, the climatic conditions were entirely suitable for this insect throughout the year. A cold period had only a momentary inhibiting effect.

Bioclimatic-cabinet studies with the Mexican fruit fly were initiated in Brownsville, Texas, late in 1954, after discovery earlier that year of one adult in southern California and light infestations at several points in northwestern Mexico, including the Tijuana area. The Mexican fruit fly is indigenous to tropical and subtropical Mexico and Central America. As the Rio Grande citrus growers well know, adult flies periodically disperse from northeastern Mexico into the lower Rio Grande Valley of Texas, where they may occasionally cause damage to the winter citrus crop.

The Mexican fruit fly, a hardy, subtropical species, produces several generations a year, but like the Hawaiian species, has no stage that undergoes diapause or hibernation. The female deposits eggs in the host fruit, which is citrus in the Valley. The larvae feed and burrow in the pulp, and when mature they migrate from the decaying fruit and enter the soil to pupate. When the adults emerge, they force their way up through the soil to begin a new life cycle.

In the insectary at Brownsville, maintained at 75-80° F., Mexican fruit fly eggs hatch in 3½ to 4½ days, the larval stage lasts from 10 to 12 days, and the pupal period 16 to 19 days. The adult preoviposition period is 12 to 16 days with flies fed protein hydrolysate, sucrose, and orange juice concentrate, which appears to be a near-optimal diet. Adults usually live from 2 to 3 months under laboratory conditions. Under different conditions of climate workers at the U.S.D.A. fruit fly laboratory at Mexico City, Mexico, have shown that the length of these stages can be greatly extended. The incubation period for eggs has been prolonged to as much as 30 days, the larval period to 40 days, the pupal period to more than 100 days, and the pre-oviposition period to well over a month. The maximum longevity reported was 11 months for females and 16 months for males.

From the information accruing from our bioclimatic-cabinet studies, the Mexican fruit fly should be able to breed throughout most of the year in a climate such as that at Orlando, Florida. The high summer temperatures at Brownsville, Texas, and El Centro and Riverside, California, are not favorable for this fruit fly. Adult longevity was greatly reduced, and newly emerged adults were unable to reach sexual maturity and reproduce before succumbing to the heat.

Summer temperatures such as occur in the coastal areas of southern California should permit normal adult activity and, since in this region the Mexican fruit fly can breed uninterruptedly during the spring, summer, and fall, and the immature stages can overwinter, the insect should be able to perpetuate itself after becoming established in these areas. With a continuous source of fruit flies in these coastal areas some adults might be able to invade the interior valleys each fall. Hot summer weather would probably drive them back to the coast or into the foothills, or perhaps eliminate any existing infestation entirely.

Permanent populations of this fruit fly could no doubt also develop along the Gulf of Mexico and in the greater part of Florida. Adults from these areas could then disperse into the Mississippi River Valley and

northward from Florida along the southeastern seaboard, for short distances at least, during the spring and summer months. However, cold winter temperatures could be expected to annihilate populations successful in gaining a temporary foothold.

The bioclimatic studies indicate that, except for the excessive summer heat, self-sustaining infestations of all four fruit fly species could undoubtedly occur in the lower Rio Grande Valley and extend from Brownsville along the Gulf of Mexico to the Galveston area of Texas.

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Need for Both Chemical and Biological Control Of the Citrus Blackfly

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This title applies mainly to the eradication or chemical control zones, and in some cases, the newly established adjacent biological control zones. These areas are all in the northern part of Mexico. In the rest of the Republic the blackfly appears to be well controlled by its parasites.

In the eradication zone of Guaymas, there is a period of about 7 months from April to November, during which it is too hot and dry to spray with oil. Spraying, therefore, has been done only in the winter months. As a result, the infestation would be knocked down in the winter by the normal 2 or 3 applications, only to increase again during the following summer. In the summer there are, of course, more blackfly generations due to the heat.

In an attempt to hold this infestation down, an experiment was started to see how parasites and predators would work in this climate. In the region south of Guaymas, at Obregon, Navojos, Alamos, etc., one parasite, *Prospaltella opulenta*, has been giving good control for several years in most places. Because of this, the parasites and predators were mainly selected from here.

The first release of parasites and predators in the Guaymas region was made in June of 1956. By the end of the year, or 6 months later, one moderately infested grove "El Laurita" had an 80 per cent parasitization by *P. opulenta* and the infestation was greatly reduced. Several other groves and gardens in the city of Guaymas showed similar results. In the winter of 1956-1957 no oil spraying was done since only inferior oil was available and also growers refused to allow oil spraying even if good oil were available, because of the oil damage to their trees over the past 8 years. Moreover, they had noticed the results obtained with parasites in most of the region and were inclining more to biological than chemical control.

Spraying here has been done only in part of one grove since the first release of parasites. This grove, "El Pardo," has always had a very heavy infestation, more than elsewhere here. Because of insufficient parasites available in the rest of Mexico, it was impossible to control this infestation as rapidly as desired and the infestation increased and spread out. To check this increase and spread, and especially to lower the general population, certain groups of trees with low blackfly parasitization were sprayed with malathion in February of this year.

By the end of July it was difficult to encounter live blackfly forms in any of the grove, except "El Pardo" and here the infestation had been greatly reduced. In the Laurita grove, 6 men made a survey for one day and found only 37 live blackfly spirals or 185 pupae. Parasitization of this material was 95 per cent by *opulenta*. In the city of Guaymas the blackfly is now difficult to find even though no spraying has been done in over 2 years. In Empalme there are still a few uncontrolled infestations due to lack of proper releases but the parasite is now in every garden so conditions similar to Guaymas are expected shortly.

It is presumed that a concerted effort will be made this winter to eradicate this very light infestation in the Guaymas zone, probably using malathion. However, it must be borne in mind that reinfestation can take place again anytime, from the South, but with so little blackfly south of here this may be put off for some time.

In the Northeast, many infestations have been found during the past year in the eradication zone which includes Montemorelos, Linares and Victoria. Thus far, none of the blackfly material has shown any presence of parasites, implying that the infestation came by way of adults (in trucks, cars, etc.) rather than infested leaves. In Texas, the reverse was found, with one locality having a 90 per cent parasitization by *Amitus hesperidum*. In this case the infestation was apparently brought in by infested leaves from the biological control zone.

In order to obtain the most efficient control in the eradication zone I have advised releasing parasites after the final spraying and at a time when the proper host stages are present. This can be determined from the data obtained in the biological control zone around Victoria. This should give valuable information on how the parasites will work here as well as possibly holding the infestation to a minimum between surveys, which often may have a lapse of 2 or more years. The one difficulty in this procedure is the effect the parasite releases may have on the growers. There is a possibility that some or many growers might prefer to go along with biological control rather than continue the eradication spraying. This has already occurred in the Guaymas zone.

Possibly the best approach would be to class this parasite liberation in the eradication zone as merely an experiment. This probably would be best done by myself. However, I see no reason why the growers could not be convinced by scientific reasoning that parasites are only being used as an aid, along with chemicals, in the ultimate eradication.

Another important need for the use of both chemical and biological control is in the newly acquired biological-control zones, adjacent to the eradication zones, in the North. It usually takes from 1 to 4 years of trial and error with the use of parasites and predators against the blackfly before uniform and stable control is obtained. During this period certain groves or gardens may increase greatly in infestation despite what was supposed to have been adequate parasite releases. Often these parasites came from entirely different climates far to the South and could not adjust themselves quickly to the new environment. Also, dusting of cotton nearby retarded control with a resulting increase in infestation. In other cases, a grove might not have as yet the proper parasite-complex due to the insufficient time elapse for this adjustment.

In these cases, often heavy fluctuations in infestation occur in parts of a grove and with a very low parasitization. This usually occurs a year or so after the grove has been practically clean of the fly, due to parasites. Because of the nearness to the eradication zone and especially because many of the other groves in the zone never as yet have had the blackfly, it is strongly recommended that steps be taken to lower these infestations to a minimum or to a population commensurate with the amount of parasites available. This would naturally indicate use of an oil spray.

However, oil spraying is not advisable because of the possible psychological effect on the entire biological control program. Certain growers might think the biological control method was not successful since we had to resort to spraying after trying the parasites out for a year or so. As a result, very little spraying has been done to lower such fluctuations.

To take care of this problem, it was decided to pick off most of the infested leaves and burn them. This is not as big a problem as one would think. To begin with, only a small percentage of the trees in a grove are infested. The parasitization in all sectors of the grove is known. If the infested trees have a moderate infestation with parasitization less than 30 per cent, all infested leaves readily seen, are removed. If the infestation is heavy with less than 50 per cent parasitization the same applies. In small, light infestations with low parasitization, unparasitized blackfly clusters are removed. This is easily done by experienced scouts. According to the supervisors, this defoliation method is in many cases much cheaper than spraying and more satisfying to the owner. This is especially true with owners of city gardens and patios who hate the frequent spraying.

In certain cases it was possible to use chemical control to lower serious fluctuations having low parasitization and still not endanger the faith in biological control. This has occurred in groves where the Florida and California red scale had increased greatly and were injuring the fruit as well as endangering the trees. This has occurred mainly in groves adjacent to cotton fields where much airplane dusting has taken place. Likewise, the increase in blackfly here may have been due to this dusting. In general, however, I have found that parasite control of the blackfly is not seriously affected by the dusting if certain simple precautions are taken. In the above cases, a light oil has been used. This controlled the scale as well as lowered the blackfly population with no psychological effect on the biological control program.

(Presented at Mexicali Mexican-American Work Conference, Oct. 25, 1957)

Cicada Injury of Grapefruit Twigs

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Numerous one-year-old Ruby red grapefruit trees in a grove near Donna, Texas were heavily damaged by cicadas during August, 1957. While the cicada, *Diceroprocta apache* Davis, is a pest of citrus in the desert areas of southeastern United States (Quayle, 1938), cicada injury to citrus in this area has been exceedingly uncommon during the previous 6 years.

Damage to twigs was common in the two rows of trees next to an area of brush. Since no rainfall was recorded in the Valley area from June 24 to August 20, dry weather conditions prevailed during the time adult cicadas had emerged, and the tender grapefruit twigs may have been more attractive as an egg-laying site than the brush. Adult cicadas collected from the grapefruit trees were identified as *Diceroprocta delicata* Osb. var. *aurantiaca* Davis[1]. However, these adults were not observed to lay eggs in the twigs.

Twig injury was quite conspicuous (Fig. 1). The roughened punctures appeared as if a probe had been inserted into the twig and raised to give a splintering effect. Eggs were deposited in the center of the green twigs. After a period of time, leaves dropped from the infested twigs, and gumming occurred on many of the twigs. Many twigs died back a few inches below the point where the last punctures were made.

Affected twigs were brought to the laboratory for incubation. The nymphs that hatched from the eggs on September 1 were tan-colored with a tinge of red. Their front legs were greatly enlarged for digging in the soil. The nymphs were identified as cicadas, Family Cicadidae[1].

The most practicable control was to remove and burn the twigs containing the eggs before they hatch, since the nymphs spend considerable time feeding on the roots of plants.

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[1] Thanks are due Miss Louise M. Russell of Insect Identification & Parasite Introduction Laboratories, U. S. Department of Agriculture, for identification.

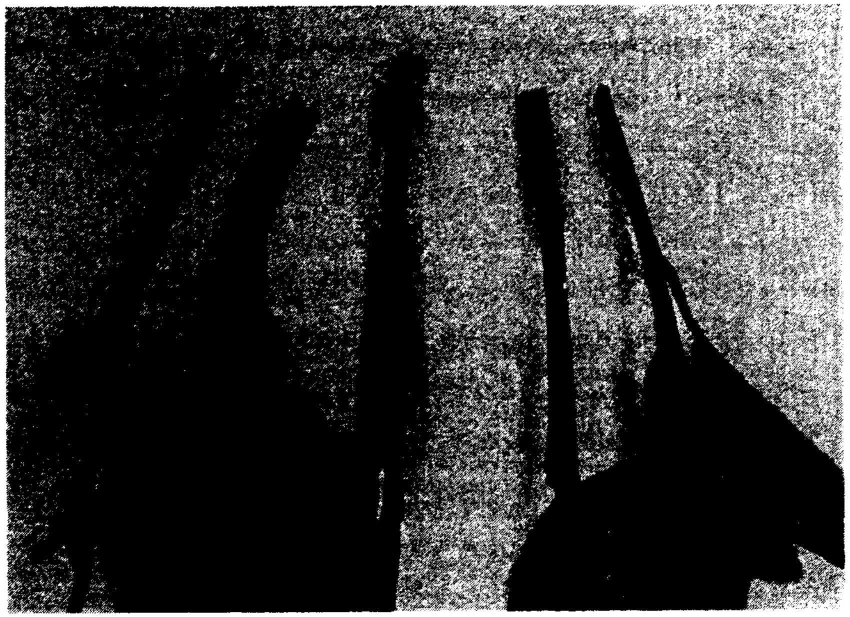

Figure 1. Grapefruit twigs damaged by cicadas. Punctured areas caused by female laying eggs.

Fertilizing Red Grapefruit in Sod Culture

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Permanent sod sulture systems in red grapefruit trees have become common in the Rio Grande Valley within the past ten years. Irrigation used is by either a permanent-border flood system or by overhead sprinkler. Sod culture is an inexpensive method of grove care, since weed control is by stalk-cutting or mowing.

After a few years of sod culture, many citrus growers claimed that the total yield of fruit is less than that from orchards where a clean- or semi-clean-cultivation and cover-crop system of management is used. The present article reports the present status of studies on the relation of fertilizer application to yield and quality of red grapefruit under sod culture.

METHODS

In the spring of 1955 a test on Webb Red Blush grapefruit was initiated to determine the effect of fertilizer additions on cold hardiness of red grapefruit trees. Different times of nitrogen applications, alone or combined with phosphate and potash or with minor element sprays, were included in the series of treatments, listed in Table 1. The effect of the various fertilizer treatments on yield and quality of fruit was also studied. Data on the effect of fertilizer application on cold hardiness is not presented at this time.

The test grove consisted of 11-year-old Webb Red Blush grapefruit trees on sour orange rootstock, spaced at 56 trees per acre. Since the trees were frozen to the soil banks in the 1949 and 1951 freezes, the tops are 7 years old. The grove was in permanent sod culture with overhead sprinkler irrigation.

Ammonium nitrate, magnesium sulphate and muriate of potash was broadcast by hand in the area two feet from the trunk to two feet beyond the drip of the tree. Treble super-phosphate was applied in a trench 4 inches deep on two sides of the tree. The trenches were then covered with soil. The zinc sulfate and manganese sulfate was applied as a single foliage spray application in February or March.

RESULTS AND DISCUSSION

The data from 1955 and 1956 on total yield, acid and total soluble solids of the fruit are given in Table 1. In 1955 the fertilizer additions had no effect on yield. The fruit from trees receiving no nitrogen (treatments 1 and 5)[1] was less acid than that on trees receiving nitrogen fertilizer. This effect of nitrogen in slightly increasing total acids is similar to that obtained in Florida by heavy nitrogen fertilization (Reuther and Smith, 1952).

In 1956 there was a substantial decrease in the yield of fruit on the no-nitrogen control trees as compared with that in 1955. On the other hand, there was a substantial increase in yield during 1956 as compared with 1955 for treatments 2 to 8. The small differences in yield in 1956 among treatments 2 to 8, all of which received nitrogen, are probably not significant; thus only an effect of nitrogen on yield is indicated.

The 1956 growing season was comparatively dry. There was very little rainfall and the supply of irrigation water was exhausted in June.

[1] The first nitrogen application to treatment 5 in 1955 occurred only shortly before the fruit was harvested.

Table 1. Effect of fertilizer treatment, started February, 1955, on yield and quality of Webb Red Blush grapefruit harvested in December, 1955, and December, 1956.

Fertilizer treatment		*Yield per acre*		*Total soluble solids*		*Total acids*	
Times N applied[a]	*Other fertilizer added in January*	*1955*	*1956*	*1955*	*1956*	*1955*	*1956*
		Tons	Tons	%	%	%	%
1 None (control)	None	6.3	1.1	9.9	11.7	1.1	1.4
2 Jan., Sept.	None	5.1	7.6	9.9	11.8	1.3	1.6
3 Jan., May, Sept.	None	5.4	6.7	9.8	12.0	1.3	1.5
4 Jan., May, Nov.	None	5.6	5.7	10.0	12.2	1.3	1.7
5 Nov.	None	6.5	7.3	9.8	12.0	1.1	1.6
6 Jan., Sept.	Mg	3.4	6.4	10.0	11.8	1.3	1.6
7 Jan., Sept.	Mg[b], Zn[c], Mn[c]	6.6	7.5	9.8	11.7	1.3	1.5
8 Jan., Sept.	Mg[b], P[d], K[e], Zn[c], Mn[c]	5.9	8.6	9.8	12.2	1.3	1.5
Mean of treatments 2 to 8, inclusive		5.5	7.1	9.8	12.0	1.3	1.6

[a] 3 lbs. of N, in the form of NH_4NO_3, applied per tree per year in 1955 and 1956.
[b] 4 lbs. MgO, in the form of $MgSO_4$, applied per tree per year in 1955 and 1956.
[c] 1 percent $ZnSO_4$ and 1 percent $MnSO_4$ applied as foliage spray in January, 1955 and 1956.
[d] 5 lbs. of P_2O_5, in the form of treble super-phosphate, applied per tree per year in 1955 and 1956.
[e] 3 lbs. K_2O, in the form of muriate of potash, applied per tree per year in 1955 and 1956.

This situation is reflected in an increase in both soluble solids and total acids in the fruit for the 1956 season. The differences between treatments were small and probably not significant. Thus, seasonal factors appear to have a greater influence on fruit quality than does fertilizer treatment. Smith and Reuther (1954) report the same for citrus in Florida.

With sod culture, nitrogen can become a limiting element and additional nitrogen often must be added to provide the nitrogen requirements of the sod, as well as the tree. No change in yield or fruit quality resulted from phosphate and potash applications. Yield and fruit quality were, as in Florida with Valencia oranges (Smith and Reuther, 1954), not affected by the timing of the nitrogen applications.

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The Sizing-Up of Citrus Fruit in Relation to Available Soil Moisture[1]

George R. Schulz, Harry Pederson and Sam Deckard

The problem of citrus fruit sizes is one of the most important problems facing the Valley grower. What must I do to grow larger sizes to get premium prices? Why is my fruit smaller than my neighbor's fruit? Growers are, by no means, in agreement as to the answer of these questions. Some are of the opinion that certain cultural practices are responsible. Others emphasize certain fertilizer applications. Nitrogen, for instance, is frequently thought to be of importance in growing larger sizes. Evidently, this is not the case. More exact observations indicate that nitrogen may influence the amount of fruit (by affecting differentiation of buds into bloom or leaf buds). Nitrogen does not, however, directly influence fruit sizes. A factor of great bearing is the amount of water entering the growing fruit. This is affected by soil moisture, which, in turn, goes back to rainfall and irrigation methods.

In order to study the relation between soil moisture and fruit growth, periodic fruit measurements were made and, at the same time, the amount of available soil moisture was determined.

Four grapefruit, one from each of four trees, were marked, and the circumference of each fruit was measured twice a week with the help of a narrow steel tape (Figure 1). While measuring, the fruit should be handled with care to prevent premature dropping. Measurements should be made at the same time each morning because of the daily fluctuation in fruit size. In the morning, the fruit is at maximum size. Later in the day, under the influence of high noon temperatures, size tends to diminish.

Moisture determinations were made by the Bouyoucous moisture test method (Figure 2). The principle of the method is as follows. Gypsum blocks are buried in the soil. These blocks take on the moisture content of the surrounding soil. Within each block are two stainless steel electrodes. Wires leading to the soil surface permit determination of electrical resistance in the block. Electrical resistance varies with the moisture content of the soil. When the blocks are wet, resistance is low. As the blocks are drying, resistance increases.

With the help of a special meter, readings are made directly in per cent of available soil moisture. When the meter registers 100 per cent, the soil is at "field capacity." That means that the soil contains the maxi-

[1] Studies were made on the Harry Pederson property, North Morningside Road, on six-year-old Ruby Red grapefruit trees, in cooperation with the Texas Soil Laboratory, McAllen, Texas.

Figure 1. Measurement of fruit growth with field tape.

mum amount of water it can hold against the pull of gravity. As the soil dries out, readings drop below 100 per cent of "available moisture" until they finally reach zero, indicating "wilting point." At this point, water is no longer available for plant growth.

Moisture blocks were buried at the depth of 6 inches, 12 inches, and 18 inches. Figure 3 gives an example of fruit-growth rate and soil moisture fluctuation during the past season. Other fruit measured in the same orchard showed the same fluctuation ungrowth rate.

The lower half of Figure 3 shows the moisture fluctuation curves at six inches, 12 inches, and 18 inches below the surface. After irrigations (see vertical lines), moisture readings indicate 100 per cent or "field capacity." As the soil dries, moisture readings fall below 100 per cent. Naturally, the moisture in the six-inch layer drops more rapidly than in lower layers.

The upper half of Figure 3 shows the fruit-growth curve in relation to prevailing soil moisture conditions. Notice the rapid increase in fruit size after an irrigation. The July 10 irrigation, for instance, resulted in rapid growth to about July 28. From then on, the growth curve flattened out, and there was no increase in size. The trees, however, looked healthy. There was no wilting. Moisture absorption was sufficient to sustain the trees, but not to grow fruit.

The soil moisture condition at the time growth stopped is of interest.

Figure 2. Determination of soil moisture with Bouyoucous meter.

The moisture curve at this critical point showed that soil moisture in the first six inches was exhausted, while there was still a great deal of moisture available in the 12- and 18-inch soil layers. Evidently, moisture-absorbing activity in the first six inches was necessary to make fruit grow. The condition was very similar after the irrigation of August 22.

Valuable weeks were lost in the first part of August and in the middle of September, weeks in which fruit growth was at a complete standstill. A shallow irrigation should have been applied at the time the six-inch layer reached wilting point. Only a small amount of water would have been needed, enough to replenish the moisture lost from the upper half-foot of soil. The results, in form of premium returns from early marketable fruit sizes, would have been noteworthy.

The irrigation in October was timed right. Water was applied at the time the upper six inches went dry. There was no flattening out of the growth curve. Fruit kept on growing at undiminished rate.

During June, approximately one inch of rain fell. This did not re-

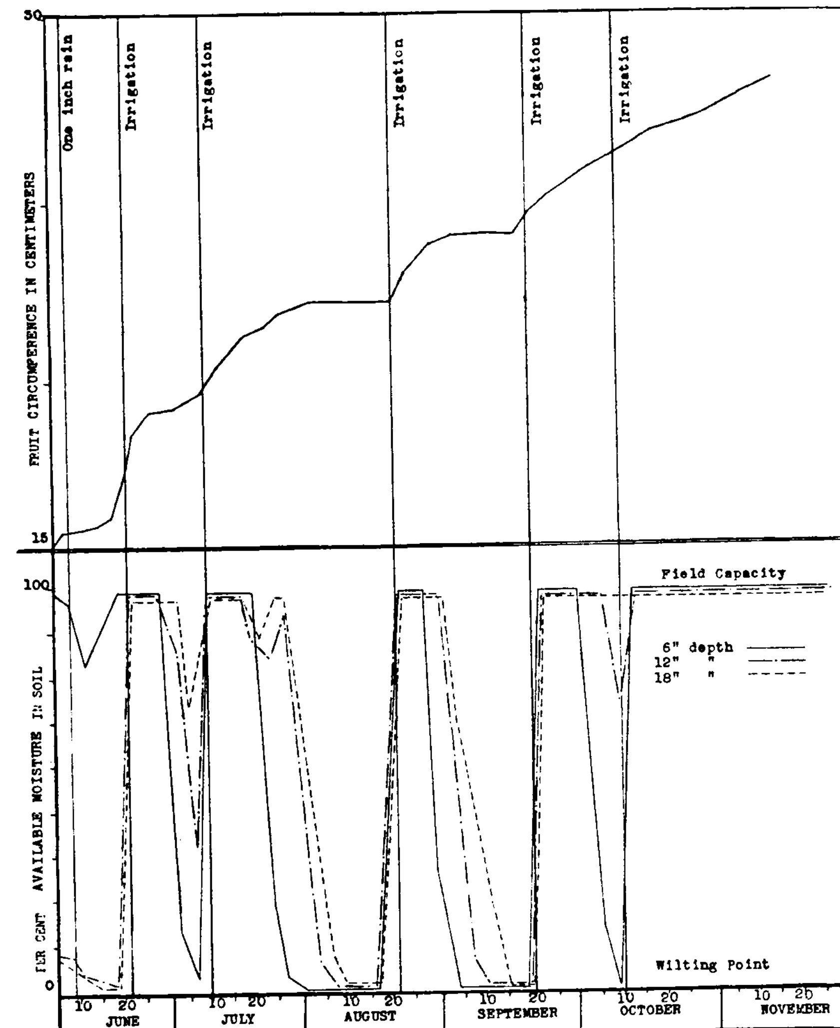

Figure 3. Influence of soil moisture changes on fruit-growth rate. Upper half: fruit growth rate from June to November, 1957. Lower half: soil moisture variations at 6 in., 12 in., 18 in., from June to November, 1957. Moisture readings were made the same time fruit determinations were conducted.

sult in increased fruit growth. At this time, the soil was dry at 12 inches, at 18 inches, and, probably at layers below. The rainfall was not sufficient to moisten a large portion of the dry root zone. This was obviously the reason why there was no decided increase in fruit growth as there was later, after irrigations. The effect of rains is often not properly evaluated. In fact, it is often over-estimated. The grower should determine whether moisture from recent rains has met subsoil moisture, or whether large areas of the root zone are still dry after the rain.

In the above example, moisture blocks were buried at 6, 12, and 18 inches, as previously mentioned. A different spacing may be advantageous in other groves. Much depends on soil type, nature of soil profile, and tree age. Even though information gained from the shallower blocks is usually more pertinent, readings in lower blocks may be of value. We have observed cases, for instance, where blocks at 24 inches stayed dry after irrigations. Fruit sizes were known to be small in the area. After measures had been taken to secure sufficient penetration of irrigation water, sizes improved. On the other hand, if blocks at lower layers are at all times at 100 per cent moisture, an undesirable condition of poor aeration and poor root activity is indicated.

In making interpretations of growth curves—their general slope, as well as more or less abrupt changes in growth rate—one must also keep in mind factors other than irrigation and rainfall. Such factors which influence the final flow of moisture into the fruit are efficiency of water transportation in the trunk and branch system of the trees, possible injury of moisture-conducting tissues (due to past freezes), distance of the individual fruit from main branches, possible salt excess (which will reduce the efficiency of moisture intake by the roots), depth of the root system, and waterholding capacity of the soil (soil structure).

Regular fruit measurements and moisture determinations are simple and practical. The information which growers can gain is valuable in many ways, leading towards more logically controlled irrigation practices. Such information will teach us to use water at the right time, where it is most needed, instead of wasting valuable water where there is already too much. Production of quality fruit and greatest efficiency of water use are, after all, two of the most important problems facing the Valley citrus industry.

Bud-Union Crease, a Citrus Disorder Associated with Some Kumquat-Hybrid Rootstocks and Scions[1]

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SYMPTOMS OF BUD-UNION CREASE

Symptoms of bud-union crease were described previously (Olson, 1954). In Texas rootstock plantings Red Blush grapefruit *(Citrus paradisi)* on calamondin *(Fortunella* sp. x *C. reticulata)* rootstock showed a disorder at the bud union. The outer bark at the bud union split horizontally along the bud union, leaving a scarred depression around the trunk. (Fig. 1C). Wound periderm formed over the remaining inner phloem tissues, and within these bark tissues necrotic pockets impregnated with wound gum formed. The inner phloem of the bark at the bud union showed gum impregnation for 2 to 5 mm. above and below the bud union; the wood at the bud union was constricted, and bark projections fitted into the wood depressions at the bud union. Below the bud union, bark and wood of the rootstock appeared normal. In 1953 bark specimens of bud-union crease from trees planted in 1950 were sent to Henry Schneider, Citrus Experiment Station, Riverside, California. Schneider examined this material after sectioning it and made the report summarized in Table 1.

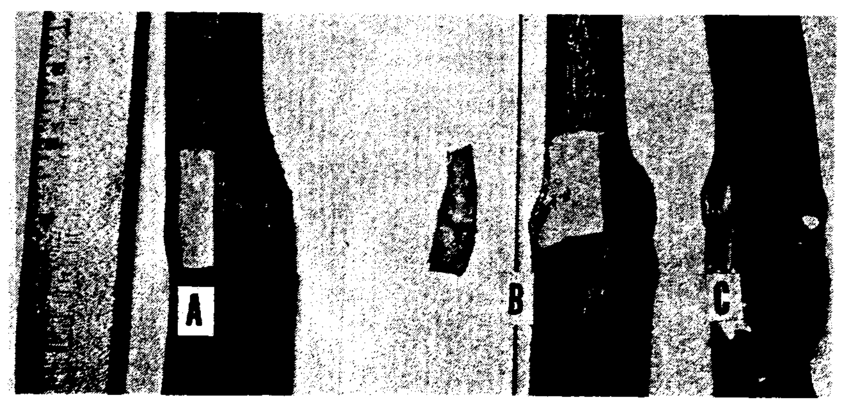

Figure 1. Appearance of bud-union of kumquat-hybrid scions and rootstocks, 31 months after budding. A. Normal bud union of Eustis limequat tops on calamondin rootstock. B. Early stages of bud-union crease of Eustis limequat tops on Sunshine tangelo rootstock. Note gum-impregnation of inner bark at bud union. C. Bud-union crease of Red Blush grapefruit tops on calamondin rootstock.

[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.

In severe cases the foliage of the grapefruit top showed vein yellowing similar to that associated with girdling; some such trees subsequently died. The foliage of other trees affected with the disorder has remained apparently normal, and the trees continue to be productive. Trees affected with the disorder commonly formed many rootstock suckers below the bud-union crease; this also is a characteristic associated with girdling. If such suckers were allowed to grow after the top died, the resulting tree showed no visible evidence of virus-caused disorders.

Trees of Shary Red grapefruit and Valencia orange *(C. sinensis)* on calamondin or lemonquat *(Fortunella* sp. x Meyer lemon) rootstock showed the same disorder noted on Red Blush grapefruit on calamondin rootstock. Two Red Blush trees on Tavares limequat *(Fortunella* sp. x *C. aurantifolia)* set in 1947 also showed similarly discolored phloem at the bud union in 1951, when the trees were removed. Budded seedlings of Glenn citrangedin (calamondin x citrange *(Poncirus trifoliata* x *C. sinensis))* were killed in the nursery by the 1951 freeze; these seedlings also showed deep indentations of the wood at the bud union. The rootstocks listed as susceptible to this disorder, including the calamondin, are considered to be kumquat hybrids (Olson, 1954).

PROCEDURE AND RESULTS

Since seedlings of calamondin, lemonquat, red grapefruit, and sweet orange grew normally, whereas certain budded combinations showed bud-union crease, it seemed possible that the disorder was related to interaction between specific rootstock and scion varieties. It then seemed desirable to determine whether the disorder was of virus origin and whether other scions were susceptible.

Table 1. Functioning phloem at or near the bud union of red grapefruit trees on sour orange and kumquat-hybrid rootstocks.

Old-line red grapefruit on indicated rootstock	*Disease visible*	*Sample*	*Width of functioning phloem at indicated point from bud union* — *6 mm above bud union*	*at bud union*	*6 mm below bud union*
Sour orange planted 1947	None	A	450	425	300
		B	300	285	270
Calamondin planted 1947	Bud-union crease	A	250	0[a]	300
		B	300	0[b]	300
Lemonquat planted 1950	Bud-union crease	A	450	0[c]	300
		B	500	0[d]	900

[a] Lesions formed at the bud union are then isolated by wound periderms.
[b] Only parenchyma was present at the bud union, and it protruded into the wood.
[c] No sieve tubes were present at the bud union; only parenchyma cells were present. Parenchyma cells died at the union of grapefruit and lemonquat, and periderm formed on the faces of the grapefruit and lemonquate tissues.
[d] Parenchyma block at bud union.

Occurrence of bud-union crease when different scions were grown on calamondin rootstock.

One-year-old calamondin seedlings at Rio Farms, Inc., Monte Alto, Texas, were budded on March 11, 1955, with the scions listed in Table 2. A group of 5 calamondin seedlings were left as controls. These seedlings were then grown for 2 years at nursery spacing, 18 inches between trees and rows 7 feet apart. On March 13, 1957, the trees were examined for first symptoms of bud-union crease. The bark was cut through to the cambium and a strip approximately 1 inch long and ¼ inch wide was peeled from the trunk at the bud union. Brown discolored phloem, 2 to 5 mm. wide, at the bud union, was considered evidence that the initial stages of bud-union crease had developed.

As shown in Table 2, bud-union crease developed on those trees with nucellar and old-line tops of grapefruit and Valencia orange. It developed when nucellar tops were used and in the absence of xyloporosis and exocortis. Thus, the causal agent of bud-union crease is independent of those bud-transmitted viruses customarily screened out by the use of nucellar seedlings. Bud-union crease did not develop when 3 limequat sources and 1 Meyer lemon source were used as scions (Fig. 1A).

Occurrence of bud-union crease symptoms on Eustis limequat trees grown on various rootstocks.

Budwood was obtained from an apparently healthy Eustis limequat tree on Uvalde citrange rootstock, planted in 1950 near Carrizo Springs, Texas. Buds of this tree were grafted on the rootstocks listed in Table 3.

Table 2. Occurrence of bud-union crease when different scions were grown on calamondin rootstock.

Scion	*Trees in tests*	*Viruses present in scion*	*Trees with bud-union crease symptoms in inner phloem at indicated time after budding* — *24 months*	*31 months*
Variety	*No.*		*No.*	*No.*
Nucellar Red Blush grapefruit	5	None[a]	4	5
Old-line Red Blush grapefruit	5	Exocortis and xyloporosis[a]	4	4
Nucellar Valencia orange	4	None[a]	4	4
Old-line Valencia orange	3	None[a]	2	3
Nucellar Eustis limequat	4	None	0	0
Old-line Eustis limequat	1	None[a]	0	0
Nucellar Lakeland limequat	3	None	0	0
Meyer lemon	5	None[a]	0	0

[a] These bud sources have been grafted on virus-indexing rootstocks susceptible to tristeza, xyloporosis, psorosis, and exocortis in earlier trials. Except for the old-line Red Blush grapefruit source, all are apparently virus-free budwood sources.

Trees propagated at Rio Farms were dug and lined out at a 5-foot spacing at the Valley Experiment Station, Weslaco, in April, 1956. By April, 1957, bud-union crease symptoms were evident in the inner and outer bark of trees on sour orange and Sunshine tangelo (Fig. 1B) (*C. paradisi x C. reticulata*) rootstock. Eustis limequat buds from the same budsource were grafted to Mexican lime seedlings, but neither tristeza symptoms nor a vein-yellowing disease (Weathers, 1957) appeared. Even though most of the rootstocks in this test are sensitive to either exocortis or xyloporosis virus, the bud-source tree is free of them or the trees used for virus indexing are not old enough to express symptoms.

Table 3. Occurrence of bud-union crease, followed by death, on trees of Eustis limequat on various rootstocks, 24 months after budding.

Rootstock	*Trees in test*	*Trees with bud-union crease symptoms in inner phloem, 24 months after budding in Eustis limequat*	*Scion dead after 31 months*
	No.	No.	No.
Calamondin	3	0	0
Cleopatra mandarin	3	0	0
Columbian sweet lime	3	0	0
Morton citrange	3	0	0
Rangpur lime	3	0	0
Sour orange	3	3	3
Sunshine tangelo	3	3	3
Sunki mandarin	3	0	0

DISCUSSION

Behaviour of kumquat-hybrid rootstocks and scions in other areas

Examples of poor growth of trees on calamondin rootstock are numerous. In the Philippines, Valencia trees on calamondin rootstock had poor bud unions (Lee, 1925); Tahiti lime, pummelo, grapefruit and lemon did poorly on calamondin rootstock (De Leon, 1930); Temple orange and Marsh grapefruit were incompatible with calamondin rootstock in Texas (Traub and Friend, 1930; Friend et al, 1932); Marsh grapefruit trees in South Africa made such poor growth after 2 years on calamondin that they were destroyed (Marloth, 1947). Calamondin is classified as an unreliable rootstock for use in the Lower Rio Grande Valley and in the Winter Garden area of Texas (Friend, 1938; Mortensen, 1954), and in California it showed little promise as a rootstock for sweet orange, lemon, grapefruit and satsuma (Webber, 1943, 1948; Batchelor and Rounds, 1948). Trees of unidentified varieties on calamondin rootstock in California showed symptoms similar to bud-union crease, which caused trees to fail in 2 to 4 years (Anon., 1955).

However, some varieties have done well on calamondin rootstock. Oneco trees did well on this rootstock in the Philippines and had a good bud union (Lee, 1925). Nagami Kumquat trees on calamondin rootstock were compatible in Texas (Traub and Friend, 1930). De Leon (1930) recommended calamondin rootstock for lime (except Tahiti), orange, and mandarin in the Philippines. De Leon's observations on orange tops do not agree with those of Lee. The calamondin is used as a rootstock in the Changchou region of China (Tanaka, 1932); scion variety was not specified, but Webber (1948) implied that mandarin scions were used. A strain of Meyer lemon that did poorly on sour orange did well on calamondin (Baker, 1934); this Meyer lemon strain probably carried tristeza virus. Kumquat scions are commonly grafted to calamondin rootstock by commercial nurserymen in Texas.

Kumquat hybrids have not done well on sour orange rootstock. In Florida limequats succeeded on any common rootstock expect sour orange (Robinson and Savage, 1934). Calamondin and Eustis limequat were "uncongenial" on sour orange rootstock in Texas (Traub and Friend, 1930). A tristeza-infected calamondin on Cleopatra mandarin rootstock grew well in Texas, but the area immediately above the bud union showed projections from the inner bark that fitted into wood depressions (Olson, 1955).

Some of the erratic behavior of kumquat-hybrid tops and rootstocks may be due to factors other than disease. The calamondin rootstock is moderately tolerant to salt toxicity, to high lime soils and to cold injury; calamondin is one of the first plants to show evidence of boron toxicity as seedlings, scions, or rootstocks (Cooper et al., 1956).

Calamondin is not the only rootstock with incompatibility reactions when sweet orange scions are used. Mendel (1956) reported a bud-union scar on Shamouti orange on Rough lemon in Israel. Grimm et al. (1955) in Florida describe a bud-union abnormality of sweet orange scions on Rough lemon rootstock with characteristics similar to the inner-phloem discoloration associated with bud-union crease. Grant et al. (1957) noted similar bud-union symptoms in Brazil.

Incompatibility symptoms in other fruits

The symptoms of bud-union crease when grapefruit or Valencia is grown on calamondin rootstock resemble symptoms occurring when pear is grown on quince stock (Mosse and Scaramuzzi, 1956). All pear-quince unions showed a well-marked dark-brown separation layer between the outer bark of pear and quince. All pear-quince unions showed some microscopic evidence of uncongeniality in the form of abnormal proliferation of the phloem rays and of necrotic cells occurring singly or in groups in the bark or very close to the union. The largest amount of necrotic tissue occurred in the 2-year-old and older phloem. The hypothesis advanced by Mosse and Scaramuzzi is that breaks in the pear-quince continuity arise when lethal substances, which accumulate in the older phloem near the union, are able to reach the cambium. This view is in substantial agreement with conclusions by Herrero (1951).

De Stigter (1956) studied the nature of incompatibility between muskmelon scions grafted on *Cucurbita ficifolia* rootstock and rejected virus infection as a possible cause; the occurrence of a substance genetically inherent to the melon and highly toxic to the rootstock was considered improbable. De Stigter concluded that the absence of a specific essential substance, enzymatic or hormonal in nature and formed by rootstock leaves, prevented the rootstock phloem from performing its functions properly.

Possible cause of bud-union crease of calamondin

The present studies demonstrated that bud-union crease develops when either nucellar or old-line clones of Valencia orange and red grapefruit are grown on calamondin rootstock. Since the nucellar strains are presumably virus-free, it seems possible that the causal agent of bud-union crease is not a virus. The cause may be the biochemical differences between some *Citrus* and *Fortunella* species and hybrids; a toxic substance, normal to one component, or the absence of a substance essential to one component, may cause bud-union crease on grafted plants of some scion-rootstock combinations.

The relation of bud-union crease, if any, to bud-union difficulties with Rough lemon rootstock in Florida, Brazil, and Israel is not known. Likewise, the relation of bud-union crease to the failure of presumablv virus-free nucellar Eureka lemon trees on Troyer citrange rootstock (Weathers et al., 1955) is unknown. In the case of disorders occurring on nucellar scions on Troyer citrange or calamondin rootstock, any virus present must be seed-transmissible or readily transmissible by mechanical means or by a vector.

If bud-union crease is caused by uncongeniality of certain scion-rootstock combinations in the absence of virus, which seems probable, then it should be possible to grow sweet orange or grapefruit scions on kumquat-hybrid rootstocks by using Cleopatra mandarin as an interstock, or "sandwich." Cleopatra mandarin appears to be compatible with grapefruit, sweet orange and kumquat-hybrids, such as limequat or calamondin. Such a scion-interstock-rootstock combination or its equivalent would test the hypothesis that bud-union crease is a form of uncongeniality not related to a virus.

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Prevalence of Viruses Causing Xyloporosis (Cachexia) and Exocortis (Rangpur Lime Disease) in Apparently Healthy Citrus Trees in Texas[1]

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Rootstock tests carried on since 1946 have disclosed that viruses causing no apparent symptoms are present in grapefruit and orange trees on sour orange or Cleopatra mandarin rootstocks (Cooper et al, 1956). Apparently healthy red grapefruit and sweet orange trees were found to carry viruses causing gum stain, pitting, and pegging in Orlando tangelo (cachexia) and sweet lime (xyloporosis) as well as bark shelling in Morton citrange (exocortis) and Rangpur lime rootstocks (Rangpur lime disease).

Since budwood sources used in rootstock tests carried these viruses, it seemed important to determine whether other clones used as budwood-source trees also carried them or were virus-free. Such information would be of value to research workers, nurserymen, and growers. The present article describes the present status of virus-indexing tests in progress and presents evidence that hidden viruses are more prevalent in Texas than previously reported (Olson and Shull, 1955, 1956; Olson et al, 1957; Sleeth, 1958).

METHODS AND MATERIALS

No psorosis or tristeza virus symptoms have been detected in the bud-source trees listed in Table 1, and their progeny have grown well on sour orange and Cleopatra mandarin rootstocks. Most of them are registered as psorosis-free by the Texas Department of Agriculture and are now being used as sources of budwood by commercial nurserymen. The red grapefruit trees listed have been widely used as budwood sources.

Buds from these apparently healthy trees were propagated on one or more of the following virus-indicator rootstocks: Columbian sweet lime for xyloporosis, Orlando or Sunshine tangelo for cachexia, Morton citrange for exocortis and Rangpur lime for Rangpur lime disease. Since the plant material available for indexing varied from year to year, many source trees were budded on only one or two rootstocks; others were

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations at Weslaco, Texas, sponsored jointly by the Texas Agricultural Experiment Station and the United States Department of Agriculture. Rio Farms, Inc., Monte Alto, Texas, cooperates in these studies.

budded on a wide range of rootstocks. Some of the tests are not yet complete.

The plants in this virus-indexing program were set out in various spacings. Those budded in 1952 were set out at a 14x5 foot spacing. Plants propagated since 1952 were similarly spaced or have been left at close spacing in the nursery row.

The test trees were grown at Monte Alto and Weslaco and observed for psorosis symptoms in the foliage and for development on the rootstocks of bark-shelling symptoms of exocortis and Rangpur lime disease or the gum stain in the inner bark and pitting and pegging of the wood and inner bark characteristic of cachexia and xyloporosis. The phloem discoloration which is very pronounced in cachexia-infected Orlando tangelo trees was either absent or much less marked in sweet limes infected with xyloporosis (Childs, 1956).

RESULTS AND DISCUSSION

Every old-line grapefruit tree tested on tangelo or sweet lime rootstock was infected with cachexia and xyloporosis, respectively, as expressed on the rootstock; many were also infected with virus causing Rangpur lime disease and exocortis of Morton citrange rootstocks (Table 1). No virus-free old-line grapefruit clones were found. However, grapefruit seedlings, which had never been budded with old-line grapefruit buds, were virus-free, as indicated by failure to produce symptoms on indicator plants (Fig. 1). Some sweet orange trees carried one or more viruses (Figure 2); others were virus-free trees.

These bud-transmitted viruses stunt Valencia orange trees on symptom-expressing rootstocks (Olson et al, 1957). Such rootstocks are undesirable for use with virus-infected tops, but might be highly satisfactory if the Valencia top were virus-free. Virus-free nucellar grapefruit trees on Rangpur lime or sweet lime rootstocks are larger than those on sour orange rootstocks, but virus-infected grapefruit trees are smaller (Fig. 1).

Since the trees tested represent a cross-section of the bud-source trees in commercial use, the results of the work to date indicate that in Texas many citrus trees carry one or more hidden viruses. They also indicate that budwood free of psorosis virus is not necessarily free of other viruses.

The results are in general agreement with those obtained in Florida, where cachexia virus was present in 62 percent of the sweet orange and grapefruit trees tested (Childs et al, 1955). Exocortis, which occurred in some Texas-grown lemons, also occurred in some California-grown lemon trees (Bitters et al, 1954).

The present results are also in agreement with the hypothesis of Childs (1956) that xyloporosis and cachexia are caused by the same virus. Of 145 trees indexed, there were 30 on both sweet lime and Orlando (or Sunshine) tangelo. In 16 cases both sweet lime and Orlando were posi-

Table 1. Prevalence of virus diseases in commercial citrus varieties in Texas as indicated by development of indicated diseases in budded rootstocks by January, 1958[a].

			Absence (O) or presence (X) of			
Budwood-source group and variety	*Budwood trees tested*	*Year trees budded*	*Rangpur lime disease on Rangpur lime*	*Exocortis on Morton citrange*	*Xyloporosis on sweet lime*	*Cachexia on Orlando or Sunshine tangelo*
GRAPEFRUIT, RED:	*No.*					
Ballard Red	1	1952	O	–[b]	–	X
Ballard Red	2	1954	X	–	–	–
Curry Red Radiance	2	1952	–	–	–	X
Curry Red Radiance	6	1954	X	–	–	–
Fawcett Red	1	1952	O	–	–	X
Fawcett Red	1	1954	X	–	–	–
Goodwin Red	1	1952	X	–	–	X
Henninger Ruby	1	1952	–	–	–	X
Henninger Ruby	1	1954	O	–	–	–
Henninger Ruby	4	1954	X	–	–	–
Henninger Ruby seedling	1	1954	O	–	O	O
Riddle Red Gold	1	1952	–	–	–	X
Riddle Red Gold	4	1954	X	–	–	–
Riddle Red Gold	1	1954	O	–	–	X
Shary Red	1	1952	–	–	–	X
Shary Red	3	1954	X	–	–	–
Webb Red Blush	3	1952	X	X	X	X
Webb Red Blush	1	1952	O[c]	O	X	X
Webb Red Blush	1	1954	X	–	X	X
Webb Red Blush	4	1954	–	–	–	X
Webb Red Blush	8	1954	X	–	–	–
Webb Red Blush seedlings	1	1952	O	O	O	O
Webb Red Blush seedlings	3	1954	O	–	O	O
Webb Red Blush seedlings	6	1954	–	–	–	O
Webb Red Blush seedlings	3	1954	O	–	–	–
Unidentified strains	11	1954	X	–	–	–

Table. 1 (Continued)

Budwood-source group and variety	Bud-wood trees tested	Year trees budded	Absence (O) or presence (X) of: Rangpur lime disease on Rangpur lime	Exocortis on Morton citrange	Xyloporosis on sweet lime	Cachexia on Orlando or Sunshine tangelo
GRAPEFRUIT,	No.					
WHITE or PINK:						
Duncan	1	1955	–	–	X	X
Foster	1	1955	X	–	–	X
Foster	1	1955	X	–	–	–
Marsh	1	1952	O[c]	O	X	X
Marsh	7	1954	X	–	–	–
Marsh Pink	1	1954	–	–	–	X
Marsh Pink	9	1954	X	–	–	–
LEMONS:						
Kennedy	1	1955	X	–	–	–
Lisbon	1	1955	X	–	X	X
Meyer (tristeza-free)	1	1954	O	–	O	O
SWEET ORANGES:						
Jaffa	2	1952	X	X	X	X
Jaffa	1	1955	X	–	–	–
Jaffa	2	1956	–	–	–	X
Lue Gim Gong sport (Texas seedless)	1	1954	X	–	X	X
Marrs	1	1954	O	–	O	O
Pineapple	1	1954	X	–	X	X
Pineapple	1	1954	X	–	–	X
Rico No. 1	1	1956	–	–	–	X
Ruby seedling	1	1954	O	–	O	O
Shamouti	1	1955	–	–	X	X
Summerfield navel	1	1954	–	–	–	X
Summerfield navel	1	1955	–	–	X	–
Texas navel	1	1955	–	–	–	X
Valencia	3	1952	O	O	O	O
Valencia	1	1952	X	X	X	X
Valencia	4	1954	–	–	–	X

Table. 1 (Continued)

Budwood-source group and variety	Bud-wood trees tested	Year trees budded	Absence (O) or presence (X) of: Rangpur lime disease on Rangpur lime	Exocortis on Morton citrange	Xyloporosis on sweet lime	Cachexia on Orlando or Sunshine tangelo
	No.					
Valencia	10	1954	–	–	–	O
Valencia	3	1955	X	–	–	–
Valencia nucellar	1	1954	O	–	O	O
Valencia nucellar	6	1954	–	–	–	O
Washington navel	1	1955	X	–	–	–
MISCELLANEOUS:						
Chinese shaddock	1	1955	–	–	X	X
Orlando tangelo	1	1954	O	–	O	O
Ponkan	1	1955	–	–	X	X
Rangpur nucellar	1	1955	O	–	O	O
Temple "orange"	1	1956	–	–	–	X

[a] Portions of the data in this table have been published by Olson and Shull (1955, 1956); Olson et al (1957); and Sleeth (1958).

[b] Dash (—) indicates an absence of data.

[c] The Rangpur lime shows cachexia-like symptoms when cachexia-infected but exocortis-free tops are used. Thus, the Rangpur lime is also an indicator plant for cachexia, particularly in the absence of exocortis.

tive and in 14 cases both were negative. In no case was one positive and the other negative. These results also are in agreement with the hypothesis of Moreira (1955) that the bark shelling diseases of Rangpur lime and of *Poncirus trifoliata* and some of its hybrids (i.e., Morton citrange) are caused by exocortis virus. However, the numbers involved in these studies were small and may not have contained all the factors.

The indicated prevalence of these "hidden" viruses in budwood used by commercial nurserymen strongly suggests that at least a majority of the citrus trees in Texas are carrying one or more viruses. The extent of the damage caused by such virus infection is not known, since at present there is no information on the effect of these hidden viruses on the productiveness of grapefruit and orange trees grown on symptomless sour orange or Cleopatra mandarin rootstocks. In the case of red grapefruit, the major variety in Texas, the only known virus-free trees are nucellar seedlings; these trees are so young that only limited yield and growth data have been obtained. Virus-infected red grapefruit trees on sour orange rootstock have been the basis of a successful industry in Texas. Since virus-free trees might prove even more productive and more

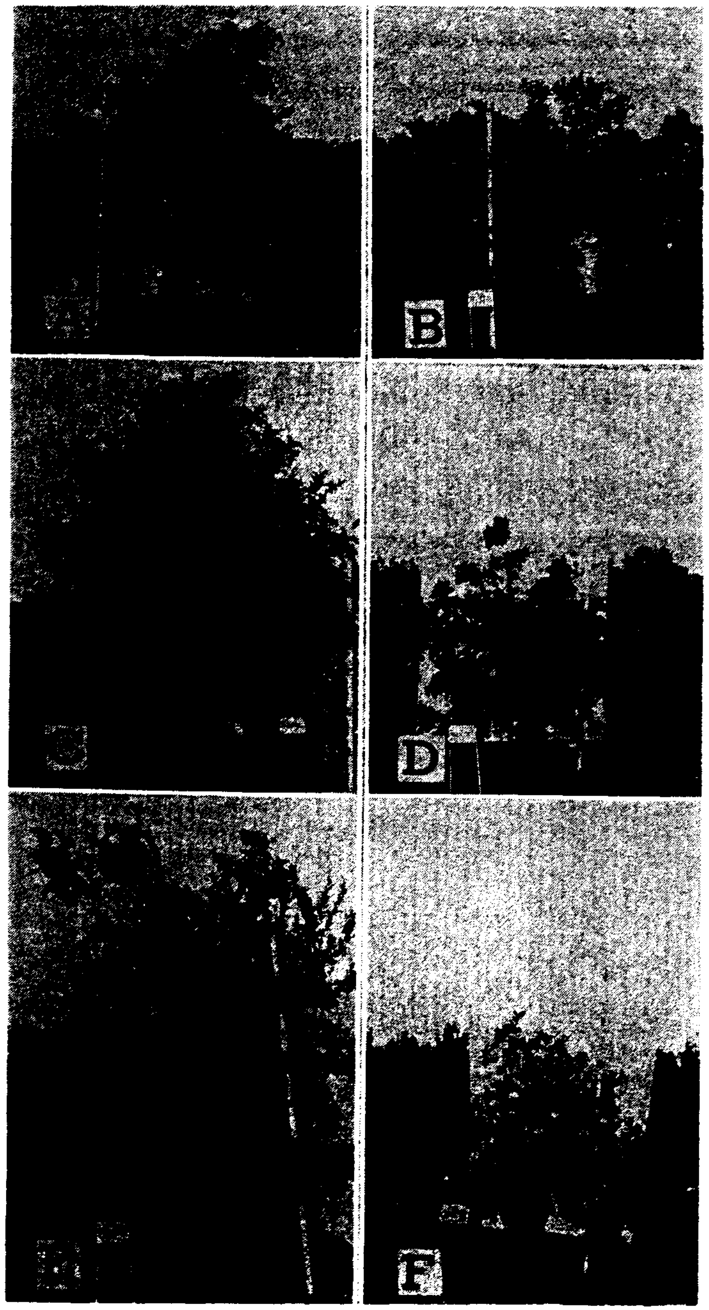

Figure 1. Relative sizes of nucellar and virus-infected Webb Red Blush grapefruit trees 6 years after budding on 3 different rootstocks at Rio Farms.

A, C. E: Nucellar trees, virus-free, on sour orange (A), Columbian sweet lime (C), and Rangpur lime (E) rootstocks.

B, D, F: Old-line trees, propagated from a single tree (R3, T4, Hoblitzelle Ranch), which had no visible effect on sour orange rootstock (B), but caused xyloporosis on Columbian sweet lime (D) and bark shelling (exocortis) on Rangpur lime (F) rootstocks. *Photographs by Bob Warren.*

cold-resistant on sour orange or other rootstocks, it becomes a matter of prime importance to find and test such trees.

The present approach to this problem is to search for virus-free trees among the commercial varieties, to produce virus-free nucellar seedlings, and to bring into Texas budwood from virus-free trees, especially from nucellar seedling trees with good performance records, from other citrus-growing areas. These introductions also include new hybrids from California and Florida. Evaluation of the detrimental effects of symptomless viruses on citrus trees in Texas awaits comparisons of the performance of virus-infected and virus-free trees on virus-tolerant rootstocks.

SUMMARY

Budwood-source trees in common usage in Texas are known to be free of psorosis and tristeza viruses. Apparently healthy budwood-source trees were indexed for these viruses by propagating them on one or more indicator rootstocks; Orlando or Sunshine tangelo for cachexia, Columbian sweet lime for xyloporosis, Morton citrange for exocortis, and Rangpur lime for Rangpur lime disease. Every old-line grapefruit tree tested on tangelo or sweet lime rootstock was infected with cachexia and xyloporosis; many were infected with the virus causing Rangpur lime disease and exocortis. Some old-line sweet orange trees were free of these bud-transmitted viruses; others were not. Nucellar grapefruit, sweet oranges, and Rangpur lime trees, as well as an old-line Orlando tangelo and one Meyer lemon, showed no evidence of virus infection.

The results of this trial are in agreement with the hypothesis of Childs that xyloporosis and cachexia are caused by the same virus; they also agree with the hypothesis of Moreira that Rangpur lime disease and exocortis are caused by the same virus.

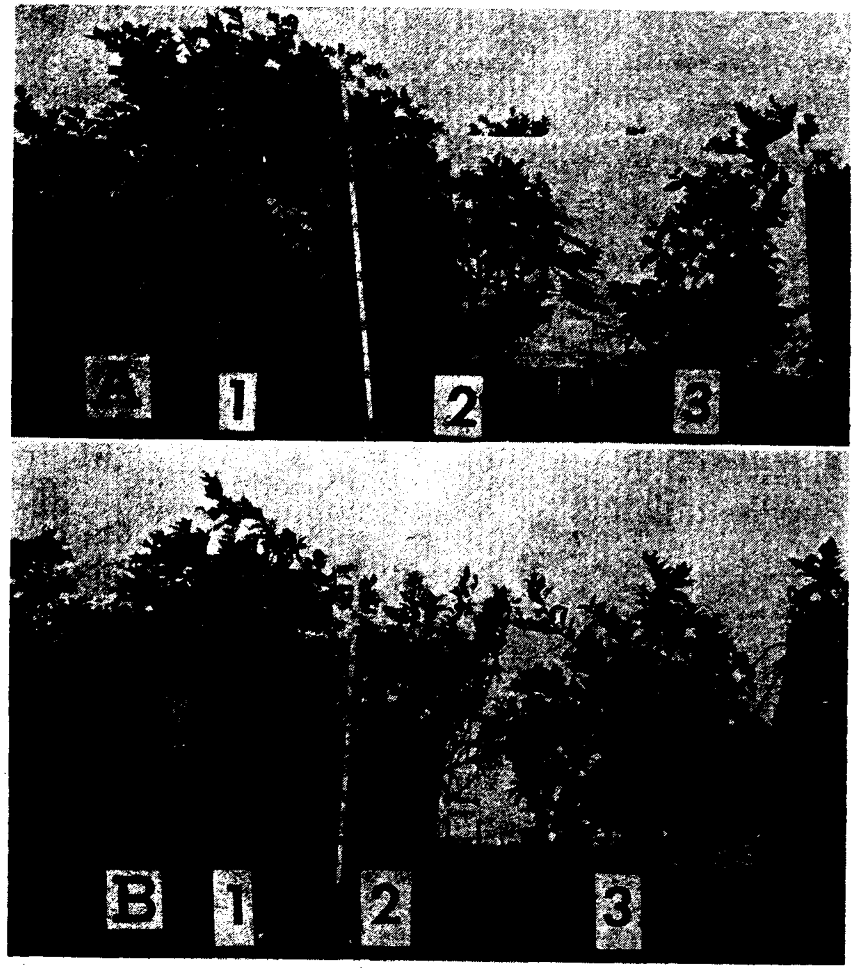

Figure 2. Relative sizes of virus-infected and apparently virus-free old-line sweet orange trees, 6 years after budding on 2 different rootstocks at Rio Farms.

A-1 and B-1: Valencia orange trees, propagated from a single tree (R2T20, Rio Farms), on Columbian sweet lime (A-1) and Rangpur lime (B-1) rootstocks. The bud-source tree is free of the viruses causing exocortis, Rangpur lime disease, xyloporosis and cachexia.

A-2 and B-2: Joppa orange trees, propagated from a single tree (R29T17, Rio Farms), with xyloporosis on sweet lime (A-2) and exocortis on Rangpur lime (-2) rootstocks. The bud-source tree carries the viruses causing exocortis, Rangpur lime disease, xyloporosis and cachexia.

A-3 and B-3: Valencia orange trees propagated from 1 tree (R8T21, Rio Farms), with xyloporosis on sweet lime (A-3) and exocortis on Rangpur lime (B-3) rootstocks. The bud-source tree carries the viruses causing exocortis, Rangpur lime disease, xyloporosis and cachexia. *Photographs by Bob Warren.*

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Nursery and Orchard Performance of Nucellar Seedling Clones of Citrus in the Rio Grande Valley of Texas[1]

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INTRODUCTION

In most citrus species, several seedlings may be produced from a single seed. One of these may be a hybrid or zygotic seedling produced by the usual sexual process. The others, called nucellar seedlings, are produced from the cells of the nucellus outside of the actual egg cell, and no male cells contribute to their formulation. These nucellar seedlings, therefore, not only inherit from the seed parent alone, but are actually identical with it in genetic composition. For example, Frost (1943) found that 223 seedlings grew out of 207 Marsh grapefruit seed and 96 per cent of these were nucellar and 4 per cent were zygotic.

Nucellar seedlings exhibit a remarkable vegetative invigoration, which diminishes with increasing age of the tree (Swingle, 1927). Several factors contribute to this invigoration. Some of the invigoration may be due to changes in the hormone status of the plant, since gibberellic acid can induce this invigoration and thorniness on old-line varieties (Cooper, 1958). Also, nucellar seedlings of certain varieties of citrus are initially free of certain viruses; thus the increased vigor may be due to absence of viruses (Cameron and Johnston, 1949). Virus-free clones can be obtained from some infected old-line varieties by means of nucellar seedlings (Fawcett, 1948).

Nucellar embryony obviously has great importance in relation to the production of both virus-free rootstocks and virus-free scion varieties. The practical value of such nucellar clones as rootstocks was demonstrated by Webber (1923, 1932), and the culling of weak seedlings is now a generally accepted commercial practice. Increasing interest is now being shown in nucellar seedlings as virus-free scion clones (Bachelor and Cameron, 1949; Cameron and Soost, 1953; Bitters et al, 1956). The present paper presents some observations on nucellar seedling clones of citrus in the Lower Rio Grande Valley and discusses certain aspects of nucellar embryony in relation to the citrus rootstock project.

[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.

Growing Nucellar Seedlings in the Nursery

Seed of some varieties, such as the Temple orange, King mandarin, Clementine tangerine, Meyer lemon, and Umatilla tangor produce few to no nucellar seedlings and a high proportion of zygotic seedlings. In Texas such varieties have been found to be unsatisfactory for rootstocks because of the extreme variability of the seedling population. On the other hand, most varieties of sour orange, Rough lemon, grapefruit, sweet orange, and mandarins produce a high proportion of uniformly vigorous seedlings. According to Frost (1943), most of the zygotic embryos in the seeds of these varieties are suppressed in the seed by nucellar embryos, and the seedlings produced may be all or nearly all from nucellar embryos. It is also possible that either fertilization rarely occurs, or that abortion occurs very early in the development of the zygote of such varieties (J. R. Furr, personal correspondence). Such seed parents will "breed true" with respect to all or nearly all its offspring. Varieties of citrus producing a high percentage of nucellar seedlings are frequently referred to as polyembryonic varieties.

The reported percentage of nucellar seedlings produced by seeds of certain polyembryonic varieties of citrus was 100 and 85 for Dancy tangerine (Frost, 1943), 85 for Valencia orange (Frost, 1943), 96 for Marsh grapefruit (Frost, 1943), 85 for sour orange (Torres, 1936), 82 for Rangpur lime (Singh and Singh, 1955), 72 for sweet lime (Singh and Singh, 1955), and 71 for trifoliate-orange (Singh and Singh, 1955). In citrus rootstock trials in the Rio Grande Valley, no recognizable variants were found among Webb Red Blush and Cleopatra mandarin seedlings grown in the nursery row, and nearly all these seedlings are probably nucellar.

If one wishes to make certain that all zygotic seedlings can be recognized, it is necessary to perform controlled pollinations using pollen from a distinctly different parent, such as the trifoliate-orange, which transmits a recognizable characteristic to its hybrid progeny (Cameron and Johnston, 1949). In the case of red grapefruit and most of the citrus varieties commonly used as rootstocks, this procedure hardly seems necessary.

Orchard Performance of Nucellar Seedlings

Orchard trials with nucellar seedlings date back to seed of 16 citrus varieties planted in California by H. B. Frost in 1915-1917 (Frost, 1952). The seedlings of all orange, grapefruit and lemon varieties were conspicuously more vigorous and more erect in growth, were more thorny, and were less inclined to early fruiting than old-line clones of the same varieties (Frost, 1938). According to Frost (1938), the fruits of the nucellar clones have a general tendency to greater elongation, greater firmness, fewer seed and earlier onset of over-ripeness changes. The fruit size, percentage of juice and chemical composition remain about the same as those of old-line clones.

In 1949 and 1951 orchard plantings of 5 nucellar clones of Valencia oranges were made by Bitters et al (1956) in California. The parent trees of these clones include Frost Valencia-A, a second budded generation of the original seedling planted by Frost in 1917; Frost Valencia-B a third budded generation from the original tree; Cutter Valencia, original nucellar seedling of seed planted in 1935; Campbell Valencia, first budded generation of seedling from seed planted in 1942; and Clark Valencia, estimated to be a very old Valencia seedling. The results of these trials indicate that the farther removed the trees are from the seedlings, both as to budded generations and time, the less thorny they are and the more precocious they are in fruit production (Bitters et al, 1956). Yield and fruit-quality records have not been published on these experiments.

Orchard trials with nucellar clones in the Rio Grande Valley date back to a planting made at the Texas Agricultural Experiment Station, Weslaco, Texas, in 1940, by Wood (1940). Buds were taken from 4-year-old seedlings of Thornton tangelo and Valencia orange and budded on sour orange rootstock. These trees are now 17 years old and are slightly taller and more erect than old-line clones of those varieties. Thorniness is largely limited to an inner zone of branch growth evidently produced in the first three seasons after planting in the orchard. The fruit on these trees are similar in size, shape and quality to that of old-line clones of the same varieties, planted at other locations. The yield of fruit, however, is low; but this is attributed to the fact that the planting was made in a date grove that shaded the citrus trees excessively. It is significant that the nucellar Thornton tangelos are free of psorosis, while the old-line parent tree is infected by the blind pocket strain of psorosis. The nucellar Valencia trees also appear to be virus-free in virus-indexing trials now in progress.

In 1950, 24 unbudded 2-year-old Webb Red Blush grapefruit seedlings were planted in the citrus rootstock orchard at Rio Farms, Inc., Monte Alto, Texas. These trees produced rank, upright and thorny growth. In 1956 the trunks of these trees were 48 per cent larger than those of old-line Webb Red Blush trees on sour orange rootstock. These seedlings were slow coming into fruiting; they produced their first crop in 1956, while old-line clonal trees on sour orange rootstock began to bear fruit in 1953. The crop on the seedlings was light as compared with that on the old-line trees. This slowness to come into fruiting is generally more marked in young nucellar clones than in old-line clones of most varieties of citrus (Frost, 1938).

The size and shape of fruit produced on the Webb Red Blush seedlings closely resembled those of fruit produced by the old-line clone. It had a red blush on the rind and the flesh color was as red as that of the old-line clone. On the basis of color changes in the rind, the fruits of the seedlings in 1956 seemed earlier in ripening than those of the old-line clones (Table 1). The interior quality of the nucellar fruit was superior to that of the old-line clone in 1956, but was about the same in October and December 1957. The first few crops, even on old-line young trees, usually develop erratically, and it may be several years before a normal pattern in fruit quality is developed.

Table 1. Characteristics of fruit harvested from budded old-line Webb Red Blush grapefruit trees and unbudded Webb Red Blush seedlings.[a]

Date of analysis and scion-rootstock	External Characteristics			Internal Characteristics					
	Weight of fruit	Diameter of fruit	Color of fruit	Thickness of rind	Volume of juice	Brix reading on juice	Acid content of juice	Brix-acid ratio of juice	Taste test on fruit sections
	gm.	inches	b	mm.	ml/100 gm. fruit	%	%		c
October 22, 1956:									
Old-line Webb Red Blush on sour orange	310	3.5	4.5	5.3	43.1	10.3	1.28	8.0	68
Old-line Webb Red Blush on Webb Red Blush	361	3.7	7.0	5.5	42.7	10.4	1.22	8.5	81
Unbudded Webb Red Blush seedling	410	3.9	7.0	5.8	44.6	10.2	1.11	9.2	85
December 3, 1956:									
Old-line Webb Red Blush on sour orange	319	3.5	4.1	5.7	43.5	10.0	1.31	7.6	66
Old-line Webb Red Blush on Webb Red Blush	331	3.6	6.8	5.0	42.4	10.5	1.27	8.5	79
Unbudded Webb Red Blush seedling	404	3.8	7.0	5.8	45.5	10.3	1.14	9.1	85
January 27, 1957:									
Old-line Webb Red Blush on sour orange	321	3.5	4.9	5.5	41.2	10.1	1.36	7.5	61
Old-line Webb Red Blush on Webb Red Blush	358	3.6	7.0	5.0	39.9	10.5	1.32	8.0	79
Unbudded Webb Red Blush seedling	418	3.8	7.0	5.8	44.7	10.7	1.16	9.3	81
October 21, 1957									
Old-line Webb Red Blush on sour orange	428	3.9	4.4	5.7	37.4	10.3	1.37	7.5	74
Old-line Webb Red Blush on Webb Red Blush	384	3.7	4.2	5.9	36.9	10.2	1.49	6.8	68
Unbudded Webb Red Blush seedling	345	3.6	4.0	6.5	36.0	10.7	1.30	6.8	71
December 9, 1957:									
Old-line Webb Red Blush on sour orange	396	4.0	7.4	4.5	42.2	10.1	1.24	8.2	31
Old-line Webb Red Blush on Webb Red Blush	479	4.0	6.8	6.1	44.4	10.0	1.61	7.7	79
Unbudded Webb Red Blush seedling	426	3.8	7.2	5.8	40.6	10.5	1.54	7.5	79

[a] Trees planted in April 1950 at Rio Farms, Inc., Monte Alto, Texas. The date given represent means of analyses on 4 replicate samples, each replicate composed of 30 fruit. These analyses were conducted in cooperation with F. P. Griffiths and Bruce Lime, U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas.
[b] Based on color of grapefruit rind standards (Harding and Fisher, 1945).
[c] A numerical rating of 70 is the minimum stage of acceptability by the consumer.

Numerous other plantings of unbudded red grapefruit seedlings have been made in the Rio Grande Valley during the past 10 years. Among those that have produced fruit are trees of the Shary Red strain grown by A. H. Law at McAllen, Curry Red Radiance strain grown by Harold Randle at Mission and Henninger Ruby Red strain grown in the citrus rootstock orchard at Rio Farms, Inc., Monte Alto. The tree and fruit characteristics of these seedling strains are similar to those reported here for the Webb Red Blush seedlings. A planting of seedlings of other commercially grown strains of red grapefruit on sour orange rootstock was made by Norman Maxwell at the Texas Agricultural Experiment Station in 1954 and a planting of 1500 young nucellar clones of the Webb Red Blush strain, budded to Cleopatra mandarin rootstock, was made by P. W. Rohrbaugh at Texas Arts and Industries College in 1954. These have not borne fruit so far.

A project to evaluate nucellar seedlings of many citrus varieties was initiated during the past year by members of the staff of the Texas Agricultural Experiment Station, Texas Arts and Industries College and the U. S. Department of Agriculture. Locally grown citrus seedlings have been propagated on sour orange rootstock. Nucellar seedling clones grown in California have been introduced and propagated on sour orange rootstock. These trees were planted this year in test plots located at the Texas Agricultural Experiment Substations at Weslaco and Crystal City; at Texas Arts and Industries College, Weslaco; and at Rio Farms, Inc., Monte Alto. An estimate of the value of these nucellar clones awaits the results of these tests.

Selection of Rootstocks for Nucellar Strains of Red Grapefruit

The presence of xyloporosis and exocortis viruses in the old-line clones of red grapefruit prohibits the use of all rootstocks sensitive to one or both of these two viruses; some of these are otherwise promising rootstocks (Cooper et al, 1957). The elimination of these viruses in nucellar seedlings of Webb Red Blush, Valencia orange and Ruby blood orange has been demonstrated by Olson and Shull (1955, 1956). It therefore appeared that the use of these virus-free nucellar seedlings as scions would greatly simplify the selection of rootstocks adapted to local soils and climate.

In February 1954 trees on 11 rootstock varieties (Table 2) were budded from 3 young nucellar clones (B, C and D) of Webb Red Blush grapefruit and one old-line clone (A) of registered (psorosis-free) Webb Red Blush grapefruit. The bud source for nucellar clones B and C was two 4-year-old Webb Red Blush seedlings, while that for clone D was a 3-year-old first-budded (to Clementine mandarin rootstock) generation from a 1-year-old Webb Red Blush seedling.

The trees were planted at 25 x 25-foot orchard spacing in January 1956. There were 12 trees of old-line clone A on each rootstock and four trees of each of the nucellar clones B, C, and D. The trees were planted in four replications of three-tree blocks, half of the blocks containing

three trees of the old-line clone and half containing one tree each of the three nucellar clones.

Recent data on these trees, which are now about 4 years old from budding, show that the nucellar trees averaged 31 per cent larger tree trunks and 23 per cent taller than old-line trees (Table 2). The increased vigor of growth applied to all three nucellar clones; however, clones B and C were more vigorous than clone D.

The nucellar trees were also more thorny than the old-line trees. The thorniness in nucellar clone D was largely limited to the inner zone of branch growth produced during the first three years, while that for clones B and C occurred throughout the entire tree, including the terminal growth.

The rootstock variety had a marked influence on the size of the tree trunks of both old-line and nucellar trees (Table 2). The Rangpur lime and Columbian sweet lime rootstocks induced high vigor in old-line trees and exceptionally high vigor in the nucellar trees. Thus, the early vigorous growth of trees on these two rootstocks occurs on both old-line and nucellar trees. The growth promotion of old-line trees was large, but very little for nucellar trees on Rough lemon rootstock. There

Table 2. Relative size[a] of old-line and nucellar Webb Red Blush grapefruit trees grown on various rootstocks.

Variety of rootstock	Area of cross-section of trunk: Old-line	Area of cross-section of trunk: Nucellar	Height of tree: Old-line	Height of tree: Nucellar
	%	%	%	%
Sour orange	100[b]	120	100[c]	121
Cleopatra mandarin	110	141	106	130
Dancy mandarin	94	115	98	111
Sunki mandarin	98	134	98	121
Suenkat mandarin	106	123	103	121
Sunshine tangelo	114	139	104	124
Tiawanica	123	130	109	123
Rangpur lime	143	205	109	137
Columbian sweet lime	135	265	108	147
Rough lemon	139	124	109	130
Carrizo citrange	109	125	92	117
Mean	116	147	103	126

[a] Expressed as percentage of that of old-line tree on sour orange rootstock.
[b] The area of cross-section of trunk of the old-line trees on sour orange was 296 cm^2.
[c] The height of the old-line trees on sour orange was 5.42 feet.

was a moderate increase in growth of both old-line and nucellar trees on Cleopatra mandarin and Sunshine tangelo rootstock. The basis for comparison for all figures on relative size given in Table 2 is that of old-line trees on sour orange rootstock.

These data also show a smaller influence of rootstock on tree height than on size of tree trunk. Thus, the rootstock, as well as the nucellar scion, appears to have a smaller influence on extension growth than on cambial activity and resulting radial growth. With viruses presumably initially eliminated from the nucellar trees, the present experiment with nucellar clones should reveal true rootstock influences on growth.

One accepted reason for the reduced vigor of old-line trees is the presence of viruses (Fawcett, 1948). The old-line trees in the present experiment contained some viruses. Bark shelling, symptom of exocortis (Olson and Shull, 1956), occurred on the Rangpur lime rootstock trunk; xyloporosis symptoms also developed on the Columbian sweet lime rootstock trunk. Also, these trees produced off-bloom fruit in 1957. None of these symptoms were observed on nucellar trees on these rootstocks.

The comparisons reported here have been presumably between a virus-infected old-line clone and a very young, virus-free, nucellar clone. As far as is known, there are no virus-free old-line varieties of red grapefruit, and the Webb Red Blush variety used in this test is as good as the average of the 8 varieties grown commercially. How long the vigor of the nucellar clones may persist and how much fruit they will produce as compared with the best old-line clone are uncertainties of the nucellar problem at this time. Therefore, although the nucellar clones show great promise for the future, the commercial use of nucellar clones should be undertaken with the understanding that they have not yet shown superior yielding qualities in Texas.

SUMMARY

The asexual reproduction, vegetative invigoration and virus-free aspects of nucellar seedlings are discussed, and the reported high percentages of nucellar seedlings produced from seed are given for certain varieties of citrus.

Nucellar seedlings of Valencia orange, Thornton tangelo and several strains of red grapefruit exhibited remarkable vegetative invigoration and were taller, more thorny and less inclined to early fruiting than old-line clones of the same varieties. The fruit produced on these nucellar trees 6 years after planting was similar in shape, size and quality to fruit on old-line trees of the same varieties. The nucellar red grapefruit clone has a red blush on the rind and the flesh color is as red as that of the old-line clone.

The rootstock variety had a marked influence on the size of tree trunks of both old-line and nucellar clonal-line trees. The trunks of nucellar trees on Rangpur lime, Columbian sweet lime, and sour orange rootstocks were 205, 265, and 120 per cent, respectively, of the size of old-

line trees on sour orange rootstock. The rootstock also influenced the height of nucellar trees, but the influence was less than that shown for trunk size.

While the nucellar-line trees used in this study are apparently free of viruses and exhibit marked vegetative vigor, they are too young to indicate whether they will also produce superior yields of good fruit. The commercial value of the nucellar clones awaits further results of tests now in progress.

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Soil Fumigation Increases Growth of Citrus Replants

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Citrus growers in the Lower Rio Grande Valley have observed that citrus replants in a mature grove or in a replanted old grove site do not grow as vigorously as the first-planted trees. A similar problem has been recognized for many years in California and much work has been done on the cause and on remedial measures (Martin and Batchelor, 1952; Foote, 1955; Baines et al, 1956). The citrus-root nematode, *Tylenchulus semi-penetrans* Cobb. has been associated with the retarded growth of replanted citrus in California (Baines, 1950) and suspected to be a primary cause in Texas (Godfrey, 1950; Sleeth, 1952). However, there may be other contributing factors as other parasitic nematodes, soil fungi as Pythium, Phytophthora and Fusarium species, toxic substances resulting from citrus growth and a nutritional unbalance.

In California, soil fumigants such as a mixture of dichloropropane and dichloropropene, chloropicrin and ethylene dibromide gave very good results in many old citrus soils when used at the rate of 1,000 to 4,000 pounds per acre. Since these fumigants are effective nematocides, a part, if not all, of their beneficial effect may be attributed to their action as a nematocide. However, it may be that the citrus nematode is only a part of the old-citrus-soil problem, which may be considered a complex which is characteristic of soils in which citrus has grown for several years.

Experimental work was started in 1951 to find out whether a citrus-replant problem existed in the Lower Rio Grande Valley and, if so, to determine its cause and work out control measures. In a survey made by Sleeth (1952) the citrus-root nematode was found to be prevalent throughout the Valley. Control work has consisted of soil fumigant trials. This report deals with the results obtained in two such trials, (1) a screenhouse test and (2) a field test.

A SCREENHOUSE TRIAL

The test consisted of growing sour orange seedlings for 1 year in 5-gallon cans in a screenhouse. Old citrus soil from 3 locations and 1 non-citrus soil were included (Table 1). There were 5 treatments including the control, with 4 replications. After 1 year's growth, the tops, stems and leaves were harvested and oven-dry weights were obtained (Table 1).

Soil fumigation with D-D was more effective than the other treatments in increasing growth of the sour orange seedlings. This increased growth, over controls, was outstanding in the three old citrus soils—the Station, Donna and Mission. Leaching the soil with irrigation water also increased seedling growth in the four soils. The increased growth obtained by the use of the mixture of minor elements suggests a nutritional unbalance even in the non-citrus soil. At the rate used, sulfur was the least promising of the treatments. As was to be expected, soil source greatly influenced growth response.

A FIELD FUMIGATION TEST WITH ETHYLENE DIBROMIDE

Citrus trees were replanted in June 1952 at the Weslaco station in an area in which an 18-to-20-year-old citrus grove had been removed about 2 years before the soil was fumigated in December, 1951. Prior to planting, the 2-acre site was leveled and permanent borders were established with 21-foot centers and 250 feet in length. A center strip, 14 feet wide in alternate borders, was treated with the fumigant at a depth of 10 inches on 12-inch spacing at the rate of 350 pounds of ethylene dibromide per acre. Six alternate borders were not fumigated.

The psorosis-free planting stock, which came from the 1949 psorosis test nursery, included 12 trees of five citrus varieties on each of two rootstocks, Cleopatra mandarin and sour orange, and one variety on sour orange stock only. Table 2 shows the varieties planted. One tree of each variety on each rootstock was planted on a 21-foot spacing in each of the 12 borders.

Trunk measurements were taken in December, 1957, at 4 to 6 inches above the bud union. Results are given in Table 2 with size recorded in terms of the cross-sectional area of the trunk. Based on the average sizes of 6 trees in each category, the trees growing in the fumigated borders were larger than those in the untreated borders. This increase in growth ranged from 3.2 per cent for Valencia orange to 40.6 per cent for red grapefruit, both on sour orange rootstock. There was an average increase in growth of around 22 per cent for all trees growing in the fumigated soil over those on the untreated borders.

Table 1. Effect of soil treatment on the growth of 1-year-old sour orange seedlings in old citrus soil.

	Average oven-dry weight of seedlings			
	Old citrus soil			Non-citrus soil
Treatment	*Station*	*Donna*	*Mission*	*Eng. Garden*
		Grams		
Shell D-D, dichloropropane and dichloropropene mixture, 800 lbs. per acre	84.4	65.9	73.3	64.7
Leaching, irrigation water, 24-30 inches	82.4	50.5	54.5	63.7
Nutritional, N,P,Fe,Mn, Zn, Cu and K	79.0	53.5	59.7	70.0
Sulfur, 5 tons per acre, walnut size lumps	78.6	42.6	53.6	52.7
Control, no treatment	73.1	45.5	49.2	57.2

Table. 2. Comparative growth response of 5-year-old citrus trees growing in soil treated and not treated with ethylene dibromide (EDB).[1]

	Cleopatra Mandarin Stock			Sour orange Stock		
	Treatment		Growth	Treatment		Growth
Citrus top, Variety	*None*	*EDB*	*Increase*	*None*	*EDB*	*Increase*
	Sq. in.	*Sq. in.*	*Percent*	*Sq. in.*	*Sq. in.*	*Percent*
Grapefruit, Red Curry	11.2	14.0	24.7	7.6	10.7	40.7
Grapefruit, Marsh Pink	9.3	11.3	21.2	8.9	11.8	32.7
Grapefruit, Marsh White				14.7	17.7	19.8
Orange, Washington Navel	6.2	8.1	30.0	6.6	7.6	13.7
Orange, Valencia	6.7	7.8	17.0	6.8	7.0	3.2
Orange, Marrs	5.0	6.7	33.8	5.6	6.9	24.7
Average	7.7	9.6	24.7	8.5	10.3	20.21

[1] The ethylene dibromide was applied as Dowfume W-40 and was supplied by the Dow Chemical Company, Midland, Michigan.

DISCUSSION

The principal effect of soil fumigation in this field trial is believed to be in citrus nematode control. Other beneficial effects also may have occurred. Since the 350-pound-per-acre dosage of ethylene dibromide used was comparatively lighter than the effective dosage reported elsewhere, a heavier dosage might have given a greater increase in growth.

Because of the known nematocidal effectiveness of the fumigant used, the results obtained strongly suggest that parasitic citrus nematodes may be a primary cause of slower growth in citrus replants than in the citrus trees first planted on the site, a condition that has been observed frequently by Valley citrus growers.

SUMMARY

In a screenhouse trial, one-year-old sour orange seedlings were grown in soil obtained from 3 old citrus groves and from one non-citrus area. Soil fumigation with D-D, 800 pounds per acre rate, increased the growth of the one-year-old seedlings in the 3 citrus soils 15, 44 and 48 per cent and 13 per cent in the non-citrus soil. Leaching and minor elements were less effective in increasing growth and sulfur was the least beneficial of the 4 treatments.

In a field test, which consisted of 72 orange and 60 grapefruit trees on either Cleopatra mandarin or sour orange rootstocks, one-half of the trees were grown in soil that had been treated with 350 pounds per acre of ethylene dibromide before planting. After 5 years the citrus trees growing in fumigated borders averaged 20 per cent larger than those in the non-fumigated borders. The increased growth ranged from 3.2 per cent for Valencia orange to 40.6 per cent for red grapefruit, both on sour orange rootstock.

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Effect of Soil Salinity on Nematodes in Citrus and Papaya Plantings[1]

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The tolerance of plant parasitic nematode populations to soil salinity is unknown. Advantage was taken of an opportunity to investigate this with citrus and papaya plantings subjected to controlled high salinity. The citrus was under such experimental conditions for three and one-half years and the papaya for one year preceding the nematological investigations. The citrus plantings were suited to studies on salinity effects on populations of the Citrus nematode, *Tylenchulus semipenetrans* Cobb, 1913, and the papaya plantings for study on populations of the Root-knot nematodes, *Meloidogyne incognita acrita* Chitwood, 1949.

Plot History Preceding Nematode Studies

The citrus plantings were of two-year-old Webb Red Blush grapefruit on sour orange and Cleopatra mandarin rootstocks at Rio Farms, Inc., Monte Alto, Texas. On each replicate plot, 6x6 feet, with sub-surface galvanized barriers, there were four trees, two on each of the two different rootstocks. The treatments or salt additives were mixtures prepared with river water and were applied with each irrigation. The additives were applied at rates producing an electrical conductivity of approximately 6.5 millimhos per cubic centimeter of soil for each of the salt treatments. The control or check treatment was of river water only, which averaged approximately 2.5 millimhos per cubic centimeter of soil during the life of the experiment. The salt treatments used were $NaCl$, Na_2SO_4, $CaCl_2+NaCl$ and $CaCl_2+Na_2SO_4$. Bi-annual leaf and root collections for analysis of salt accumulation were made to study salt tolerance of the two rootstocks. These data show a moderate accumulation of both sodium and chloride ions in the roots and leaves (Gorton et al, 1954).

The papaya plants were seedlings and were grown under an experimental plan similar to that used for the citrus. The $CaCl_2+Na_2SO_4$ treatment was not included in our assay and there were only two replications. Leaf and root collections from the papaya plants have been reported (Cooper and Peynado, 1954) to show a large accumulation of both chloride and sodium ions in both the roots and tops of the plants.

[1] The author appreciates the cooperation shown by W. C. Cooper and A. Peynado of the U. S. Dept. of Agriculture and that provided by Rio Farms, Inc., Monte Alto, Texas; also the analysis (Table 2) made by W. D. Hanson, Biometrician, Agri. Res. Serv., U.S.D.A.

PROCEDURE

In January 1956 there were collected and composited 3 two and one-half inch cylindrical soil cores to a depth of three inches from each of four replicate treatment plots. A similar set of cores were collected and composited immediately below the shallower samplings at a depth of 4 to 13 inches. The cores were taken toward the center of the 6x6 foot plots. The citrus rootlets were removed from the samples by sifting. From each composite sample was taken a standard 250 ml. soil sample for processing. The processing was by the technique described previously by the author (Machmer, 1954). Counts were made of the larvae of citrus-root and root-knot nematodes found and also of the other nematodes present, which included a few other parasitic and numerous saprophytic species. Average results of these examinations, with all salt treatments combined, are given in Table 1, and for the different salts from the shallow samples of the citrus plots in Table 2.

The citrus rootlets were washed and examined under a dissecting microscope for presence of females of the Citrus nematode. The papaya roots were dug and rated for the degree of galling induced by Root-knot nematodes. These ratings showed no appreciable difference between treatments but indicated that the citrus roots were moderately and the papaya roots heavily infected by Citrus nematodes and Root-knot nematodes, respectively.

Table 1. Number of nematodes extracted from shallow and deep sampling of citrus and papaya roots and soil after prolonged controlled high salinity.

Treatments	*Nematodes recovered per standard sample*[a]				
	Citrus-root T. semipt.	*Root-knot Meloidgyne*	*Other parasit.*	*Saprophytic & non-parasit.*	*Total nematodes*
Citrus-shallow:					
Avg. of salts	51.9	....	13.8	113.4	179.2
Avg. of check	2.5	....	2.5	37.5	42.5
Citrus-deep:					
Avg. of salts	45.6	....	2.5	29.4	77.5
Avg. of check	12.8	....	0.0	10.0	22.5
Papaya-shallow:					
Avg. of salts	....	83.3	18.3	270.0	371.6
Avg. of check	....	60.0	20.0	135.0	215.0
Papaya-deep:					
Avg. of salts	....	140.0	28.3	93.3	261.6
Avg. of check	....	110.0	25.0	55.0	190.0

[a] A standard sample is 250 ml. (15 cu. in.) of soil.

RESULTS AND DISCUSSION

The nematode counts from the citrus plots were all three or more times greater from salt-treated plots than from control plots; and for Citrus nematodes from the shallow collection the counts were 20 times greater. The counts from the papaya plots, except "other parasitic" nematodes from the shallow collections, were only slightly more to about twice as great from the salt plots than from the control plots (Table 1).

The two chief parasitic nematodes, Citrus and Root-knot, not only survived but thrived with a controlled high salinity. The counts for other nematodes generally show a superiority of numbers with the salt treatments.

The data in Table 2 indicates a consistent superiority in numbers of nematodes with Na_2SO_4 and with NaCl. A statistical analysis of population scores for the shallow citrus collection only is shown in Table 2. This analysis follows a multiple range technique (Duncan, 1955) showing homogeneous numerical values which are further identified into groups by lower case letters. The differences under "total nematodes" only are distinct, showing three groups; the nematodes in the control treatment being fewer and distinct from the number in the salt treatments. The response from the Na_2SO_4 treatment group "c" is greater than those from the other salts, with only a small difference between this and NaCl.

CONCLUSION

More total nematodes and Citrus nematodes were recovered from citrus roots subjected to a continued higher though tolerable salinity than from citrus roots grown at lower salinity levels. The same applies by lesser degree to total nematodes and Root-knot nematodes recovered from papaya roots. The present investigation shows tolerance of nematodes to salts in soils when the host plants, though impaired, still survived.

Table 2. Homogenous groupings[a] of nematode population counts from shallow citrus collections following prolonged controlled additions of the salts listed.

Treatments	*Total nematodes*	*T. semipenetrans*
Check	4.0 a	.1 a
$CaCl_2+Na_2SO_4$	11.4 b	.4 a
$CaCl_2+NaCl$	12.1 b	3.2 a b
NaCl	20.1 b c	3.2 a b
Na_2SO_4	24.0 c	7.4 b

[a] Analysis by Hanson after Duncan's multiple range technique.

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Devices For Observing Root Growth and Calipering Tree Trunks

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INTRODUCTION

The need for root-growth data on field-grown trees cannot be overemphasized. Most observations on trees in experimental orchards are limited to the tops. Since performance of the tops depends in part on performance of the roots, root observations are an essential part of tree studies.

There are several references in the literature to devices used for observations of roots of field-grown trees, but these devices were simple and were not described in detail. Crider (1927) dug large holes in the soil near field-grown trees in such a position that the tree roots came in contact with an inserted glass pane and grew along the inside surface. The holes were walled on the other sides with boards and were provided with a closely fitting cover to exclude light and retain moisture. Waynick and Walker (1930) and Schneider (1952) used similar procedures in studying root growth of field-grown trees.

Preliminary experiments conducted in the Rio Grande Valley with a root-observation device similar to that of Crider's were not entirely satisfactory. Following rains and irrigations, water frequently seeped into the holes, filling them with water, making the window muddy and causing air spaces behind it. The present paper describes a modification of Crider's root-observation device, consisting of a solid waterproof box with one or two observation windows, and presents some root-growth observations on Webb Red Blush grapefruit trees, made from September 1957 to January 1958.

Measuring the diameter or circumference of tree trunks is a standard procedure in studying the rate of tree growth; however, methods of determining trunk size vary. Some workers use a metal tape, but on large trees it is necessary to crawl under the skirt of the tree to use the tape. In Florida, H. P. Traub and T. R. Robinson[2] used a hand-made wooden caliper with handles about 3 feet long to facilitate trunk measurement. However, the short handles still made it necessary to crawl under large trees. The present paper describes a light-weight caliper made of aluminum conduit pipe, with handles 5½ feet long and with the scale on

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[1] The author appreciates the cooperation of William C. Cooper, U. S. Department of Agriculture, Weslaco, Texas.

[2] Unpublished, 1937.

the end of the handles, making it possible to measure trees from outside the skirt of the trees.

Root-Observation Box

The root-observation box is made of stock lumber yard materials as follows: 1– x 12–, 1– x 6–, and 1– x 4-inch redwood select heart lumber for the sides, bottom and top; ½– x ¾-inch window parting stop for the glass windows; 18-inch squares of ⅛-inch thick window glass; and 8d box galvanized and 3d finish nails. The dimensions given eliminate the ripping of lumber or additional glass cutting.

Figure 1A shows the assembled box with the 3-inch immersion thermometer on the side. The depth at which the thermometer is placed is optional. The arrangement of the box in place in the soil is shown schematically in Figure 2A.

The bottom of the box, Figure 1D, consists of a piece of 1– x 12-inch lumber 18¼ inches long and 4 pieces of parting stop (two pieces 16¾ inches and 2 pieces 17¼ inches long) leaving a ¼-inch channel for the glass.

The side, Figure 1C, consists of a piece of 1– x 12-inch lumber 24½ inches long and 4 pieces of parting stop 18¼ inches long. One piece is nailed firmly, on its thin side, flush with the outside edge, and the inside piece is left movable, tacked only on the ends. This simplifies the replacing of broken windows without taking the box out of the ground. Drill a 1¼-inch hole and insert a No. 6 rubber stopper with a hole for the thermometer.

The top, Figure 1B, is constructed so that it fits over the top of the box; the inside dimensions being about ½ inch longer and wider than the box. The lip of the box is made of 1– x 4-inch lumber. The insulation on the underside of the top is three thicknesses of mineral wool insulation mats held in place by a strip of parting stop anchored with three 8d galvanized box nails. This insulating material can be bought in rolls. Figure 1E shows a cross-section of the top.

All joints are made with a waterproof glue prior to nailing the sections. After the box is assembled, caulking compound on the channels makes a good seal between the wood and the glass, and the glass is slipped in place. The inside strips are then pushed snug against the glass and the top ends are nailed.

Painting of the box is optional, but it was found that unpainted boxes, although ¼-inch play is left for the glass, tend to crack the windows. This is due to the expansion and contraction of the box with the change in moisture. A white asphalt paint is recommended to prolong the life of the box, increase waterproofing and make it easier to see inside the box.

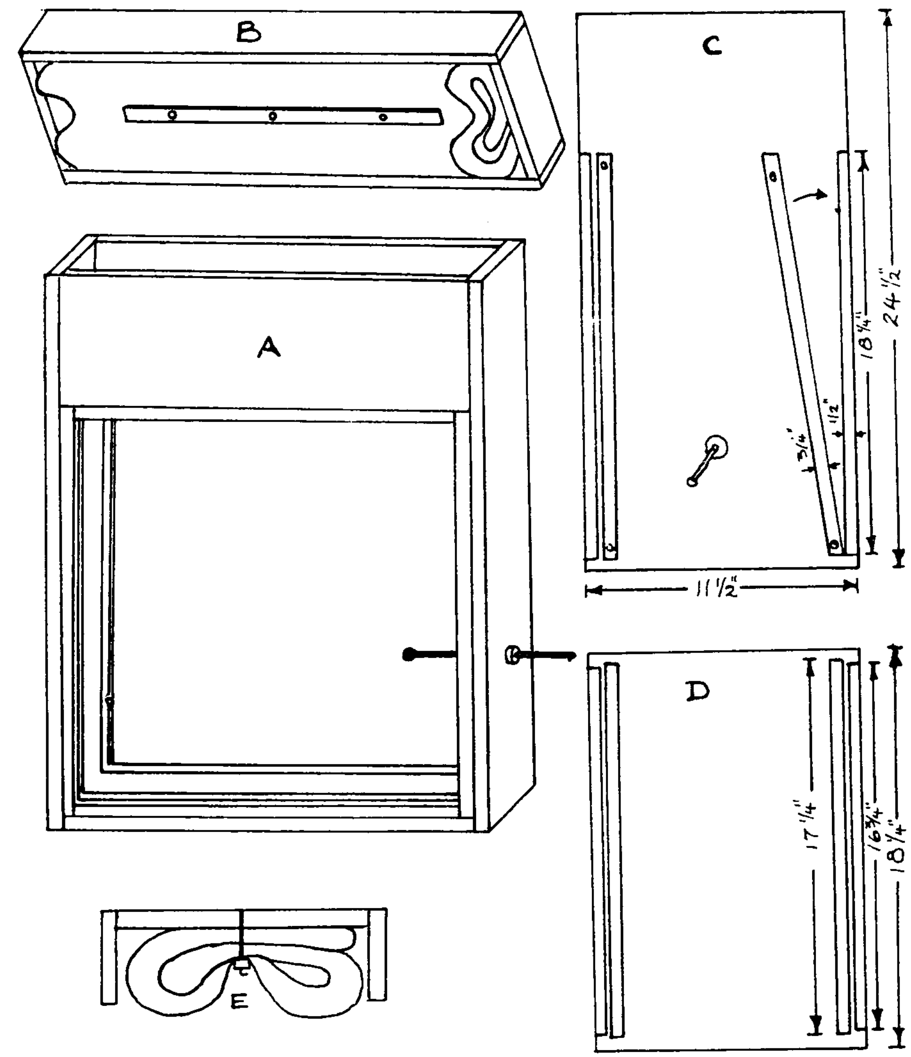

Figure 1. Drawings of the root-observation box. A shows the assembled box with a thermometer on the side. B shows the top of the box with 3 thicknesses of insulation on the under side. C shows detail on construction of the side of the box. D shows detail on construction of the bottom of the box. E is a cross-section of the top of the box.

Observations made from root-observation boxes are given in Table 1. The boxes were placed in the top 18 inches of the soil, 6 feet from the trunks of four 7-year-old Webb Red Blush grapefruit trees on sour orange rootstock. The orchard was maintained under a Bermuda-grass sod and was irrigated by a low-pressure sprinkling device. It is generally known that new growing root tips of citrus are white, while those of non-growing roots are light brown. Therefore, the number of white root tips is an index of the root-growth activity. Counting white root tips is simplified by use of a tally counter. Root growth occurred throughout the fall and winter, but was most active during late October and early November. New roots occurred throughout the top 18-inch horizon of soil at all times, but the greatest concentration of new roots was found in the top 12 inches.

Table 1. Observations on number of white root tips, made on four 7-year-old Webb Red Blush grapefruit trees on sour orange rootstock, growing under Bermuda-grass sod culture and sprinkle-irrigated at Rio Farms, Inc., Monte Alto, Texas.

	White root tips on windows			
Date of observation	*Tree 1 Number*	*Tree 2 Number*	*Tree 3 Number*	*Tree 4 Number*
September 6, 1957[a]	0	0	0	0
September 30, 1957	47	12	3	18
October 14, 1957	97	68	77	90
October 28, 1957	195	90	90	125
November 13, 1957	205	130	184	192
November 25, 1957	80	80	120	102
December 12, 1957	120	70	80	138
December 23, 1957	54	57	28	68
January 7, 1958	21	19	54	39
January 20, 1958	7	10	24	28

[a] The root-observation boxes were installed on September 6, 1957, and consequently no white root tips were observed on that date.

Tree-Trunk Caliper

The tree-caliper device, Figure 2B, is made of two pieces of lightweight conduit ½ and ¾ inches, with ½ x ¼-inch sheet-iron straps welded on the ends. The ¾-inch piece slips over the ½-inch piece. The length of the pipe can be varied and adapted to the user's needs, depending on the size trees to be calipered. The scale, Figure 2C, is etched with a punch and a chisel on the ½-inch pipe and a section cut out of the ¾-inch pipe to form an indicator point and to make at least one figure visible to the left of the indicator. The graduations on the scale

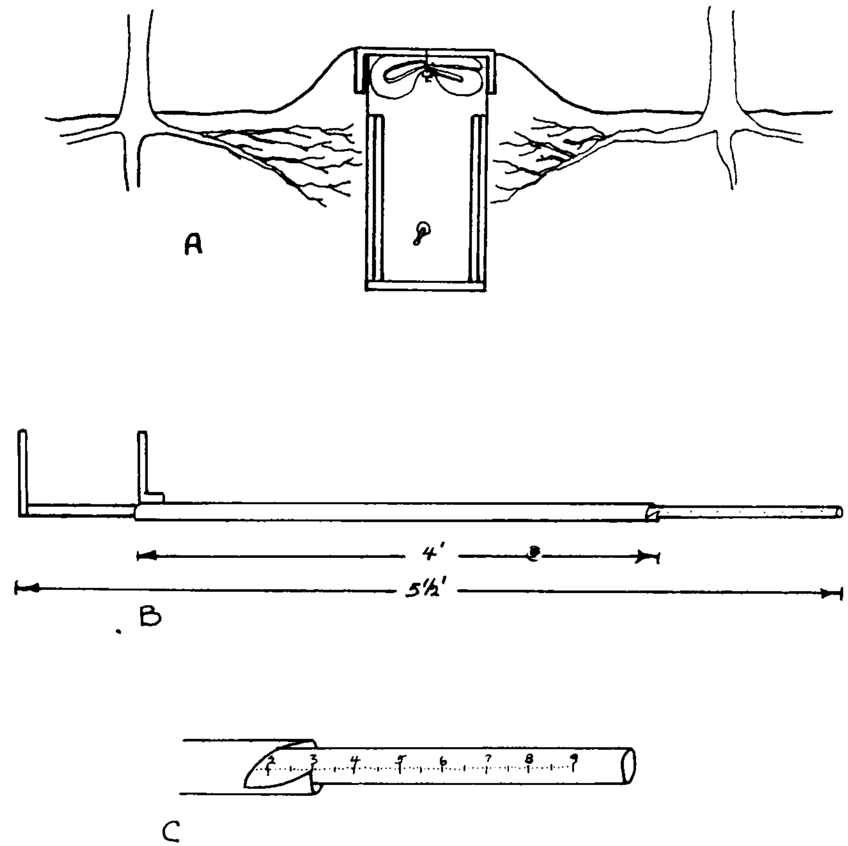

Figure 2. A is a drawing of the box located in the soil. B is a drawing of the tree caliper. C shows in detail the measuring scale on the tree caliper.

may be made to read either in tenths of an inch in trunk diameter, or in tenths of square inches area of cross section of the trunks. The latter method eliminates the usual procedure of computation of square inches area from inches diameter. The scale should be etched on the side facing up when the straps are horizontal with the ground and the zero mark should be where the pointer rests when the straps are snug against each other. This way, when the reading is taken with the pointer on the scale, the user can be positive that the straps are aligned and horizontal with the ground.

Two men, one operating the caliper and one recording the measurements, can easily caliper the trunks of trees of a 20-acre orchard in 4 hours.

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AVOCADO SECTION

The Sun-Blotch Disease of Avocado

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Unlike most economic plants, the avocado *(Persea americana* Mill.) has been found to be subject to only one virus disease. Prior to the demonstration of the virus nature of this disease (Horne and Parker 1932), the name *sun-blotch* was given to the disorder because the effects or symptoms on the trees resembled sunburn (Coit 1928). In his early description of the disorder, Coit expressed the opinion that the striped appearance of the shoots arose from the effects of the sun. The work of Horne and Parker disproved this but the name *sun-blotch* was retained for the disease.

The most detailed account of avocado sun-blotch yet published (Whitsell 1952) appeared in the 1952 Yearbook of the California Avocado Society. This present paper will review some of the information reported by Whitsell, but it will cover primarily the developments in the studies of sun-blotch since 1952, with particular emphasis being given to methods of control or prevention of the disease.

Symptoms of the Disease

The most consistent symptom of sun-blotch and the only symptom of much value in diagnosis is the streaking and spotting of the bark of twigs and limbs. Usually the streaks are yellow in color but at times, especially on young trees, the streaks may be whitish or almost colorless. On some plants experimentally infected as small seedlings, the streaks are pink or red. The streaks usually arise in line with the leaf petiole and extend in narrow bands for varying distances below. On occasions the first symptoms, particularly those developing on young budded trees, are in the form of a few small yellow spots scattered at random. The streaked areas are sometimes depressed and some vigorously growing shoots on field trees may have many depressed streaks paralleling each other so as to present a fluted appearance.

Sun-blotch-infected trees sometimes produce clusters of leaves showing marked white or pink mottle or variegation (Figure 1). The fruits of some affected trees quite commonly have depressed streaks, usually extending onto the fruit from the stem end. These streaks may be few or many. In some instances the fruits are badly marked and are small and misshaped. The number of affected fruits on diseased trees may vary from none or very few on some trees to many on others. The absence of fruit and/or leaf symptoms is thus not proof that a tree is not infected. Furthermore, as will be discussed later, it has been established that avocado trees are sometimes carriers of the sun-blotch virus without displaying any of the known symptoms of the disease.

Figure 1. Symptoms of avocado sun-blotch disease. Slight stem streaks indicated by arrows; fruit showing depressed streaks and some mature leaves with distortion and variegated patterns.

Economic Importance of Sun-Blotch

There are actually no data available regarding the economic importance of this disease. It is known, however, that infected trees generally are less productive than healthy trees. Diseased trees frequently grow into a low, flattened shape with the limbs bending toward the ground. This type of growth increases exposure and injury from sunburn. Some infected trees commonly set fewer fruits, thus reducing the yield. The streaking of fruits further reduces the marketable yield. An important loss from sun-blotch is sometimes sustained by nurserymen when sizable numbers of avocado trees grown for sale are found to be diseased. Further losses are experienced by avocado growers who purchase trees for planting and have the added expense of their care for a period of years before learning that the trees are infected.

Means of Spread of the Virus

Limited experimental studies and field observations indicate that there is no important amount of natural spread of sun-blotch virus from

diseased to healthy trees. If there is any spread by insects this has not been detected. Healthy trees can become infected as a result of a naturally-occurring root graft with an adjacent diseased tree, but nothing is known as to how frequently this takes place.

The use of diseased propagative material is responsible for most of the sun-blotch in avocado trees. The use of budwood from diseased trees results in diseased progeny trees. In some instances, too, infection comes from the rootstock seedlings as a result of seed transmission of the virus (Wallace and Drake 1953). Recent studies have revealed that certain avocado trees are symptomless carriers of the virus and that all or nearly all of their seedling progeny are likewise symptomless carriers of the virus. If grown as seedlings, these trees will never show symptoms of sun-blotch but when used as rootstocks and worked to sun-blotch-free scion varieties the resulting budlings will develop severe symptoms of the disease.

It is not known how common such symptomless carriers, which produce sun-blotch-infected seedling progeny, are. Three trees have been located in California which have been demonstrated to be of this type. Past experiences of avocado nurserymen in the State indicate that, at least occasionally, such trees have been used as sources of seed for the production of rootstock seedlings. In a number of instances, budwood from sun-blotch-free sources resulted in healthy trees when used on one rootstock source but on another rootstock source most of the resulting trees developed sun-blotch symptoms. Such reactions clearly demonstrate that the infection came from the rootstock seedlings. Experimental studies have established that an occasional avocado seedling will express sun-blotch symptoms within 3 months or longer after germination. This reaction is accepted as seed transmission of the virus and is the type known for several plant viruses. Actually, this type of seed transmission of the sun-blotch virus occurs very rarely. Numerous experiments have been completed in which seeds were harvested from many different trees showing severe disease symptoms and with many of the seed originating from fruits with severe symptoms. Less than 1 per cent of these seedlings have developed symptoms.

Thus, there are two types of virus transmission through seeds of avocado. One of these is the rare instance of transmission, as known for other viruses, in which the virus invades the growing seedling and causes expression of symptoms with perhaps more than 99 per cent of the seedlings from the same parent source being virus-free and symptomless. The second kind of seed transmission, as already mentioned, is that in which 100 per cent of the seedlings grown from an infected but symptomless parent source will likewise be symptomless carriers of the virus. If grown as seedlings, they remain symptomless and do not develop symptoms even when repeatedly reinoculated. However, by indexing the seedlings to other test seedlings it can be shown that they carry a low concentration of the virus. When a healthy scion bud is grown on these infected seedlings, the scion growth eventually develops sun-blotch from the virus which moves up from the rootstock.

Prevention of Sun-Blotch

Control of sun-blotch is strictly a matter of prevention. To have healthy trees one must plant healthy trees. The propagator of avocado trees therefore must know that both the scion variety parent source and the rootstock parent are free of sun-blotch. Accurate diagnosis for the disease can be made only by indexing. This involves inoculation or transmission tests which unfortunately require several months to complete. There is no short-time test as in the case of many plant viruses. After inoculation or infection with the virus, an avocado test seedling requires from 3 months to 2 years to express symptoms of sun-blotch.

To test for sun-blotch in a tree selected as a bud source, it is recommended that buds or scions from the candidate tree be grafted to at least 10 avocado seedlings which are preferably about 3 to 5 months from germination (Wallace 1950). Decapitate the seedlings, leaving two or three buds above the inoculum. Observe the new growth for 6 months and again remove most of the top to force new growth. If, after an additional 6 months, none of the inoculated seedlings have developed sun-blotch symptoms, the chances are very good that the candidate tree is not a carrier of sun-blotch virus.

With the exception of the variety Zutano, which appears to be slow in developing symptoms, there appears to be no particular difference between avocado varieties in susceptibility to sun-blotch. Mexican varieties appear to be as susceptible as the Guatemalan varieties, but our observations indicate that the latter varieties generally develop symptoms somewhat earlier after experimental inoculation.

It has already been emphasized in this paper that avocado trees may be symptomless carriers of the sun-blotch virus and that some of these symptomless carriers produce seedling progeny, all of which may be infected and are undesirable for use as rootstocks. A candidate rootstock parent tree can be indexed for sun-blotch in two ways. The first of these is as described for budwood parent trees, i.e., indexing on healthy avocado seedlings. The second test involves the budding of a known sun-blotch-free scion variety on 25 seedlings from the rootstock candidate source and observing the budlings for symptoms for a period of 1 year. This test can be done in the greenhouse or in the field. A method of speeding up this test is to grow the seedlings in pots in the greenhouse, budding with the healthy scion variety while the seedlings are young (pencil-size or smaller) and transplanting later to nursery rows in the field. This test can be completed in the greenhouse but growth is usually better if transplanted to the nursery.

A nurseryman can make this test himself entirely under field or commercial conditions if he desires to do so. Seedlings of the candidate rootstock parent can be lined out and budded in the field. However, there are two requisites for accurate diagnosis. First, the budwood used must come from a source known to be free of sun-blotch. Second, the operator must know how to read the early symptoms of sun-blotch or have the services of a person trained to identify the symptoms. When

infection results from virus that is carried by the rootstock seedlings, the first symptoms usually appear as very small yellow spots close to but above the bud union. These spots gradually enlarge and increase in number and later the more typical streaks will begin to appear on the growth higher up on the tree. The trunks of budling trees grown for this indexing under field conditions must be shaded from direct sun by tree wraps or burlap in order to prevent sunburning, which masks the early-appearing yellowish spots caused by the sun-blotch virus.

SUMMARY AND CONCLUSIONS

Sun-blotch is the only known virus disease affecting avocado. No appreciable difference in susceptibility between varieties has become apparent. There is a suggestion that the variety Zutano may be somewhat more resistant than other varieties, but this may be largely a matter of time required for symptom expression. Observations on varietal reaction indicate that the Guatemalan varieties as a group express symptoms somewhat earlier after inoculation than the Mexican varieties, but the total percentage of infection and severity of symptoms do not differ between the two groups.

Stem streaking and spotting are the only consistently reliable symptoms for diagnosis of the disease. Some trees are symptomless carriers of the sun-blotch virus. The absence of symptoms on field trees is no certain proof of their freedom from infection.

There is no known natural spread of the sun-blotch virus other than possible root grafting between diseased and healthy trees.

Sun-blotch infection results from the use of either diseased budwood or rootstock parent trees for propagation of young trees. Seed transmission of the virus may be of two kinds. One of these is the rarely-occurring transmission of the virus which results in typical symptoms developing on a seedling grown from seeds from an obviously diseased tree. Other seedlings from the same source will be symptomless and virus-free. The second type of seed transmission is that known in three specific cases and suspected in several other instances in which the seedling progeny from infected but symptomless trees is infected to the extent of 100 per cent. Such seedlings never express symptoms but if used as rootstock will cause sun-blotch to develop on the scion growth of the variety worked on them.

Control of sun-blotch is a matter of prevention. The propagation of diseased trees can be avoided if both budwood and rootstock source trees are determined to be free of the causal virus. This can be done by proper indexing procedures which can be made easily but which require approximately 1 year to complete.

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Sunblotch in Avocado Introductions From Texas

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Suspected sunblotch infection of several avocado clones introduced into Texas from Mexico several years ago has provoked an examination of progeny from these clones now growing in California.

Along the south fence of the Los Angeles campus orchard is a row of fifty Mexican seedlings from a single tree source planted about 1935. These trees have been used as rootstocks for testing and observing clones from various sources. None of these seedling rootstocks showed any evidence of sunblotch prior to topworking, but after grafting six trees have developed symptoms during the past seven years. Four of these six, adjacent to each other, were topworked in November, 1950, to scions of Graham-Arsola selections (1-2W; 15-8), Santa Engracia and Castro 6A, respectively, all of which were received as bud sticks taken from trees of these varieties grafted onto West Indian rootstock and grown at Harlingen, Texas. These four trees show sunblotch symptoms in the sucker limbs which have been allowed to develop below or adjacent to the scions. The scions in each case do not show symptoms of sunblotch.

The remaining two trees which show symptoms of sunblotch each has grafted on it a rather unusual variegated sport of local origin, which was noted about six or seven years ago and thought to be a mutant of interest to students in horticulture. Apparently this variegant is a possible carrier of the sunblotch virus, though leaf distortion and twig symptoms sometimes associated with sunblotch are not well defined or are lacking. Growth on the scions during the past few years has been practically normal and most of the variegation has disappeared, but clearly marked symptoms of sunblotch have developed on the suckers from the rootstock.

Another scion from Texas in the same row of seedlings does not show sunblotch, nor do other limbs on the mother tree. This scion, of the variety Prior from Uvalde, may have come directly from Uvalde, Texas, or from a tree growing elsewhere in California.

These observations suggest the possibility that the four scion varieties from Harlingen, Texas, are symptomless carriers of sunblotch virus. The Texas-grown arees are budded progeny from seedling trees in northern Mexico. These observations, while limited, have stimulated interest in sunblotch studies in Texas and have provided a clue to the possible cause of a rootstock disorder occurring when some varieties of Mexican origin are grown on West Indian rootstock.

Azteca—A Bud-Perpetuated Rootstock Disorder of Some Texas-Grown Avocados

Edward O. Olson,[1] Norman Maxwell,[2] and W. C. Cooper[1]

Many avocado selections from Mexico, Florida, and California have been introduced into the Rio Grande Valley during the past 12 years (Cooper and Maxwell, 1956). The object of these introductions was to find selections whose production, salt tolerance, cold tolerance and disease tolerance were superior to those of varieties already grown in the Valley. Scions of these selections were grafted on West Indian seedlings, since trees on this rootstock have greater salt tolerance than those on seedlings of the Mexican race (Cooper, 1951). The progeny were grown in test orchards at one or more locations to determine their performance in the Lower Rio Grande Valley. As the trees grew older, it became apparent that the trees of certain selections on West Indian rootstock were subject to a rootstock disorder, for convenience called azteca.

Symptoms and distribution of azteca

Azteca is characterized by deep grooves in the bark of the West Indian rootstock of young trees (2-6 years of age) when certain varieties are used as scions (figure 1). When other scions are used, the rootstock has bark as smooth as the top. In older trees, roughening of the rootstock bark may be due to natural causes.

Many of the trees with azteca are comparatively stunted in growth; others are not. No distinctive foliage symptoms such as those for sunblotch-virus infections have been recognized on affected trees.

The disorder has been recognized in variety plantings near Weslaco, Harlingen, Rio Grande City and Monte Alto, Texas. G. D. Ruehle, in conversations in November, 1957, stated that approximately 25 to 100 Booth 8 trees on West Indian rootstock grown at Homestead, Florida, showed a similar rough bark condition on the rootstock; the affected trees were replaced. Since West Indian seedlings are not used in California, this disorder is apparently unknown there. The disorder has not been observed in Mexico, where most avocado trees are seedlings.

Relation of Azteca Symptoms to Scion Varieties

The grafted progeny of certain selections propagated on West Indian rootstock have shown azteca symptoms; others have not (table 1). The disorder is especially common in the budded progeny of seedlings

[1] Agricultural Research Service, U. S. Department of Agriculture, Weslaco.
[2] Texas Agricultural Experiment Station, Weslaco.

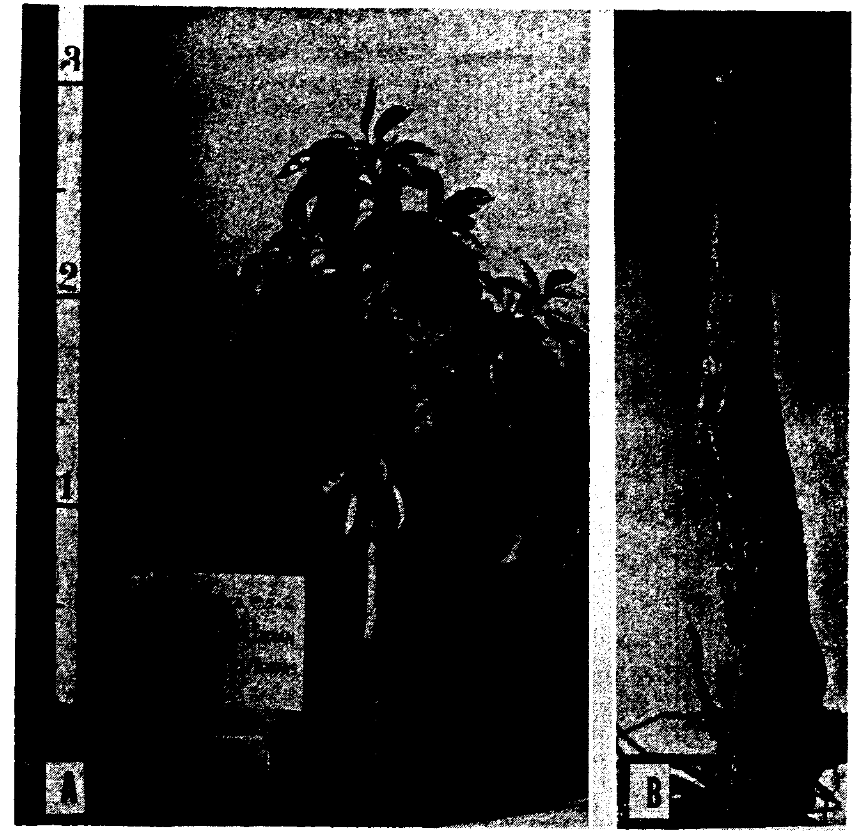

Figure 1. Symptoms of azteca on the West Indian rootstock of a tree propagated from a selection from near Llera, Tamaulipas, Mexico. A. General appearance of tree. B. Azteca symptoms (deep grooving of rootstock bark) below the bud union. No symptoms occurred on the scion.

from some areas of Mexico. Most of these seedlings were classed as hybrids of 2 races (West Indian x Mexican). Many of the trees examined for azteca were young and may subsequently develop symptoms of the disorder.

Possible Causes of Azteca

(a) *Variability of rootstock seedlings.* This possibility is rejected because the disorder has been limited to the progeny of certain budsource trees and has not been found in semi-commercial plantings with Lula tops on similar rootstocks.

(b) *Nutritional causes.* This possibility seems unlikely because the

Table 1. Occurrence of azteca symptoms on West Indian rootstocks grafted with various scions.

Scion variety or selection	*Geographic origin*	*Probable parentage*[1]	*Plants examined*	*Plants with azteca symptoms when grown on West Indian rootstock*
			No.	*No.*
Alaniz 3	Llera, Tamp., Mex.	Mex.	4	0
Allen	Mercedes, Tex.	Mex.	1	0
Arsola 1-18	Llera, Tamp., Mex.	Mex. x WI	29	18
Arsola 5-2	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 5-6	Llera, Tamp., Mex.	Mex. x WI	2	2
Arsola 7-2	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 10-2	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 12-5	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 17-1	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 17-3	Llera, Tamp., Mex.	Mex. x WI	1	1
Arsola 29-9	Llera, Tamp., Mex.	Mex. x WI	26	23
Booth 7	Goulds, Fla.	Guat. x WI	4	0
Booth 8	Goulds, Fla.	Guat. x WI	3	0
Brandt	Brownsville, Tex.	Mex.	6	0
Castro 2	Victoria, Tamp., Mex.	Mex.	136	80
Castro 3	Victoria, Tamp., Mex.	Mex. x WI	2	2
Diaz	Victoria, Tamp., Mex.	Mex. x WI	13	6
Lula	Goulds, Fla.	Guat. x WI	84	0
MacRill	McAllen, Tex.	WI	1	1
Pancho	Harlingen, Tex.	Mex.	95	0
Paz 3	Llera, Tamp., Mex.	Mex. x WI	1	1
Paz 4	Llera, Tamp., Mex.	Mex. x WI	1	1
Pryor seedling	Harlingen, Tex.	Mex.	1	0
R-1	Raymondville, Tex.	Mex.	17	0
Rodilles 2	Atlixco, Pue., Mex.	Guat. x Mex.	1	1
W-1	San Juan, Tex.	Mex.	4	0
14366	Atlixco, Pue., Mex.	Guat. x Mex.	1	0
14369	Atlixco, Pue., Mex.	Guat. x Mex.	1	0
14375	Atlixco, Pue., Mex.	Guat. x Mex.	1	0
14382	Villa Guerreo, Mex.	Mex.	1	1
14383	Villa Guerreo, Mex.	Mex.	1	1
14384	Villa Guerreo, Mex.	Mex.	1	0

[1] "Mex." refers to Mexican race, "WI" to West Indian race, and "Guat." to Guatemalan race of avocados.

disorder has not developed in semi-commercial plantings of Lula and Pancho at Rio Grande City, while adjacent trees of Castro selections on the same West Indian rootstocks showed high proportions of azteca-affected trees. As shown in Table 2, dwarfed trees on Ardilla rootstock do not show azteca symptoms.

(c) *Uncongeniality of stock and scion.* The Pancho, R-1 and W-1 selections are genetically similar to many introductions from Mexico; yet use of these 3 varieties as scions does not cause azteca, whereas use of many of the others does. Uncongeniality might be expected to produce bud-union symptoms, but not symptoms extending from the bud union to the larger roots. Uncongeniality is a possible, but not a probable, cause of azteca.

(d) *Virus.* The only known virus disease affecting avocados is sunblotch, which causes a yellow streaking of the foliage, green stems and branches and a yellow-to-red streak on the fruit. Some sunblotch-affected trees tend to have a decumbent willowy type of growth and may be stunted. Checking of the bark on mature branches and trunks is often associated, but it has not been definitely established that this is a symptom (Zentmyer, 1955). Gustafson (1956) also noted that rough and corky bark on the trunk and larger branches is sometimes, but not always, present on trees with sunblotch. With one exception, the trees observed in the various Texas plantings have shown no symptoms of sunblotch. The exception is described in Table 2. Sunblotch virus is seed-transmitted readily from some Mexican-race trees which are symptomless virus carriers (Wallace and Drake, 1953). However, Schroeder and Froelich (1958) indicate that several introductions from the Ciudad Victoria area of Mexico are sunblotch virus carriers, while other selections of Texas origin are not. There is a possibility that sunblotch virus is either associated with or perhaps is the causal agent of azteca. Support for this viewpoint is presented by the observation that the Diaz variety caused azteca on West Indian rootstock, whereas Lula tops on a Diaz seedling showed sunblotch symptoms (Table 2). However, in Ciudad Victoria, Tamaulipas, Mexico, Lula trees on West Indian rootstock showed sunblotch symptoms on the Lula top, but no azteca symptoms on the root-

Table 2. Sunblotch and azteca symptoms on certain 3-year-old scion-rootstock combinations.

Scion	*Rootstock*	*Appearance of*			
		Tree growth	*Foliage*	*Rootstock bark*	*Scion bark*
Lula (Guat. x WI)	Diaz (Mexican)	dwarfed	sunblotch	normal	sunblotch
Lula (Guat. x WI)	West Indian	normal	normal	normal	normal
Diaz (Mexican)	West Indian	normal	normal	azteca	normal
Lula (Guat. x WI)	Ardilla[1]	dwarfed	normal	normal	normal

[1] The ardilla is a wild avocado type of unknown species found in the mountains at Aguacatlan, S.L.P., Mexico.

stock. The occurrence of sunblotch in the Ciudad Victoria planting is evidence, however, that the causal virus is present in the area either naturally or introduced in budwood from the United States.

If azteca is caused by a virus separate and distinct from sunblotch, then it is apparently common in Mexico. However, abnormal bark and foliage symptoms were not recognized in West Indian, Mexican x West Indian, and Mexican-race seedlings in the Ciudad Victoria area from which most of the Mexican introductions come. Thus, some original seedlings are apparently symptomless carriers of the causal agent of azteca.

In citrus, viruses may be symptomless in a scion variety but cause roughening of bark of certain rootstocks. It seems possible that the same phenomenon may occur in avocados. Therefore, further studies of this disorder are designed to test the hypothesis that a virus is the cause of azteca disorder.

Importance of the Azteca Disease Problems

Studies on this problem are necessary to determine the following:

(a) Whether budwood introductions from other areas are virus carriers. Present indications are that some introductions carry sunblotch virus, which may or may not be the causal agent of azteca.

(b) Whether seed-transmitted diseases are being spread by Texas-grown seed of selections brought in from Mexico. Investigations on this point have been started.

(c) Whether the Azteca disorder is a limiting factor for avocados on West Indian rootstock. The semi-commercial varieties now being planted (Lula, R-1, and Pancho) on West Indian rootstock are those which do not cause the disorder.

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The Effect of Thickening Agents in Reducing the Watery Separation of Frozen and Thawed Guacamole Products

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The avocado (*Persea americana* Mill) according to Cruess, Gibson and Brekke (1951), has been used in processed products for a number of years. However, considerable difficulty has been encountered in preparing products which would retain an avocado flavor without discoloring or becoming soft.

McColloch, Nielsen and Beavens (1951) modified a household recipe of an avocado spread called "Guacamole" and reported that the addition of 8 to 10 parts lemon juice, 1 to 2 parts salt, and 0.3 part dehydrated onion powder to 100 parts of pureed avocado, retained a satisfactory color and flavor for a year in frozen storage at 0 to –10° F.

Avocado Whip, developed by Stahl and reported in Industrial South (1955) combines avocado, lime juice, salad dressing and salt into a puree suitable for freezing. The puree will retain its color longer at refrigeration temperatures than sliced fresh acocado, but will darken upon standing.

The Canner and Freezer (1957) mentions a new fresh frozen avocado paste marketed under the trade name of Kendall which is becoming popular on the Miami, Florida, market.

This product, which contains avocados, lime juice, vegetable oil, onion, salt, and monosodium glutamate, was developed through the University of Miami's Food Technology laboratory and is being manufactured by the Parman-Kendall Corp. of Kendall, Florida.

Seven varieties and 6 strains of avocados grown in the Rio Grande Valley of Texas, were tested by Stephens, Lime and Griffiths (1957) for the preparation of an avocado mixture for guacamole. Some of these varieties and strains retained a thick butter-like consistency after being frozen and thawed. Others became soft and released a watery phase. Individuals asked to evaluate the guacamole objected to the watery separation because it detracted from the appearance of the product. Freshly prepared unfrozen guacamole does not separate as badly as the frozen and thawed product. This watery separation was not mentioned by the other investigators whose publications have been briefly reviewed.

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[1] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

The objectives of the experiments reported in this paper were to determine whether thickening agents such as waxy rice flour and sodium alginate, used singly or in combination, would reduce or prevent the watery separation of guacamole; and whether they would impart an objectionable flavor.

MATERIALS AND TESTS

Avocados. Two lots of Lulu variety avocado were obtained from a planting near Harlingen, Texas. The first lot of approximately 60 pounds was obtained in November, 1956, and the second lot of approximately 200 pounds in December, 1956. Because all of the fruit was not the same stage of ripeness it was necessary to place the fruit in 68° F. storage until each fruit became soft. The soft ripe stage is considered ideal for fresh consumption. Twice each day the ripe fruit was moved to 40° F. storage and held until sufficient fruit had ripened to the desired stage for preparing an experimental batch of guacamole. At no time did the fruit remain in the 40° F. storage room for more than 3 days before use. All fruit used in the experiments was considered to be of excellent uniform quality.

Thickening Agents. Two thickening agents were tested singly and in combination in guacamole formula for the prevention of separation. These were a waxy rich flour manufactured by the Rice Products Company,[2] San Francisco, California, and sodium alginate manufactured by the Algin Corp. of America,[2] Rockland, Maine. These products were used because Hansen, Campbell and Lineweaver demonstrated the stability of waxy rice flour in prepared frozen gravies and sauces, and because sodium alginate has been used as a stabilizer in ice cream for a number of years (Sommer, 1947).

Guacamole Formula. The basic (No. 1) formula used is a modification of the guacamole formula recommended by McCulloch, Nielsen and Beavens (1951), and by Stephens, Lime and Griffiths (1957). It consisted of 94.07 per cent avocado flesh, 4.70 per cent lemon juice, 0.28 per cent onion powder, and 0.95 per cent salt. Each time other ingredients were added, the formula was recalculated so that the percentage of avocado flesh and flavoring materials remained in the same proportion.

Sensory Evaluation Tests. Only sensory evaluation tests of the experimental guacamole products were undertaken. These were made by a panel of eight members. In examining some products the panel members determined only whether each had a waxy rice flour flavor, and the degree of watery separation. In examining other products they graded each on a 10 point hedonic scale for flavor and consistency, i.e. whether thin or watery, and thick or pasty. In each series of tests a sample of guacamole made according to the basic formula (Table 1, No. 1) was used as a control.

[2] The mention of trade products or companies does not imply that they are endorsed or recommended by the U. S. Department of Agriculture over other similar products or companies not mentioned.

Waxy Rice Flour as a Thickening Agent for Frozen Guacamole

The first series of experiments in this study were to determine the mixture of waxy rice flour and water that would be most desirable to maintain or improve the consistency of guacamole. Test batches of 5, 10, 15, 20, 30 and 40 per cent waxy rice flour were mixed thoroughly with water; heated in a double boiler with constant stirring, and cooked 3 minutes after the mixture reached the boiling point. Hansen, Campbell and Lineweaver (1951), in their studies of the preparation of stable frozen sauces and gravies, cooked the waxy rice flour mixtures for only one minute, but this procedure was modified because the "paste" appeared to be more translucent after the longer cooking time. Of the above preparations it was observed that the mixture of 15 per cent waxy rice flour and 85 per cent water produced a paste which most nearly resembled the consistency of the mashed avocados.

In a second series of experiments the 15 per cent waxy rice flour paste was incorporated in batches of guacamole in concentrations of 0, 10, 20, 30 and 40 per cent.

In preparing the paste for the guacamole the lemon juice, onion and salt were first mixed with the water and then the flour was added slowly with continuous stirring to prevent excessive lumping. The mixture was cooked 3 minutes in a double boiler and then allowed to cool. In the interim uniformly ripe avocados were peeled and mashed with a potato masher to give a rather coarse textured product. The cooled paste was folded into the mashed avocado flesh. The finished product was immediately dispensed in 6 oz. plain tin cans. These were uniformly filled

Table 1. Guacamole formulas tested in the evaluation of thickening agents.

Formula No.	Avocado Flesh (%)	Lemon Juice (%)	Onion Powder (%)	Salt (%)	Waxy Rice Flour (%)	Sodium Alginate (%)	Water (%)
1	94.07	4.70	.28	.95	....	...	....
2	75.57	3.78	.23	.76	3.02	....	16.63
3	75.57	3.78	.23	.76	2.77	.25	16.63
4	75.57	3.78	.23	.76	2.52	.50	16.63
5	75.57	3.78	.23	.76	2.27	.75	16.63
6	75.57	3.78	.23	.76	2.02	1.00	16.53
7	75.57	3.78	.23	.76	1.01	2.00	16.63
8	75.57	3.78	.23	.76	....	3.02	16.63

so as to leave a minimum head space, sealed, and frozen and stored in still air at 0° F. Ten cans of each of the five guacamole products—containing 0, 10, 20, 30 and 40 per cent of the paste mixture—were packed.

The first evaluation study was made after a three day storage period. Two cans of each frozen product were brought up to room temperature. Each member of the sensory testing panel was then presented with five portions of guacamole; one without waxy rice flour paste, and four containing the paste in the varying amounts described above. Each member was asked to designate those samples in which he could detect the flour and which would be objectionable for this reason. He was also requested to rank the samples from the most watery separation to the least. Portions of the five products were then rearranged and judged a second time. These examinations were repeated on the fourth and fifth days.

The incorporation of waxy rice flour paste in guacamole products for freezing did not reduce watery separation of the thawed products except at the higher concentrations which slightly affected flavor. Six of the eight panel members could consistently detect the presence of waxy rice flour at the 20 per cent paste concentration (15 per cent waxy rice flour, 85 per cent water), but did not consider it objectionable. All 6 considered the 30 and 40 per cent concentration objectionable. Of the two panel members who could detect the flour only at the 30 per cent paste concentration, neither thought it objectionable, but one did find it objectionable at the 40 per cent concentration. The greatest amount of watery separation occurred in the guacamole product containing 10 per cent of the paste; the least amount in that containing 40 per cent. Some separation occurred in guacamole containing 20 per cent paste, but all factors considered, this was selected as the more desirable concentration. In this experiment there was very little difference in the degree of watery separation in the control guacamole product made without waxy rice flour paste and in the guacamole made with 20 per cent paste.

The flavoring materials should be added to the waxy rice flour paste during its preparation so that all ingredients can be folded into the mashed avocado flesh in one operation with a minimum of stirring. Too much stirring not only divides the avocado flesh too finely but it also incorporates excessive amounts of air into the guacamole. The paste should be thoroughly cooled before it is added to the mashed avocado flesh. If the paste is added hot an objectionable bitterness develops in the product.

A Combination of Waxy Rice Flour and Sodium Alginate as a Thickening Agent for Frozen Guacamole Products

It was shown in the preceding series of experiments that a concentration of 20 per cent by weight of a paste containing 15 per cent waxy rice flour in frozen guacamole, reduced watery separation on thawing, but did not entirely prevent it. Experiments were therefore undertaken to determine whether the use of sodium alginate in combination

with waxy rice flour would yield a non-separating guacamole product of good consistency and flavor.

In a third series of experiments eight batches of guacamole were prepared employing the formulas listed in Table 1. The preparation procedures were the same as before except that the sodium alginate was dusted into the mixture while the waxy rice flour paste was being folded into the avocado flesh. Care was taken to obtain as uniform mixing and distribution of the sodium alginate as possible. The products were canned and frozen as in the preceding series of experiments and they were evaluated by the sensory panel after three days at 0° F.

Samples of guacamole prepared according to formula 1 through 6 were of sufficiently good quality to warrant additional study. Guacamole products containing 1.01 per cent waxy rice flour and 2.00 per cent sodium alginate (formula No. 7); and 3.02 per cent sodium alginate (formula No. 8) were unsatisfactory. Guacamole prepared according to formula No. 7 had a slick feel to the tongue and was considered objectionable. The use of 3.02 per cent sodium alginate without the waxy rice flour paste rapidly thickened the mashed avocado flesh to the extent that a uniform product could not be obtained.

In a fourth series of experiments six batches of guacamole were prepared according to formula 1 to 6 inclusive (Table 1). These were prepared from the December-harvested Lulu avocados for storage study.

After 9 months storage, three 6-oz. cans of product of each of the six guacamole products were thawed in tap water, thoroughly mixed, and portions served to taste panel members. Each member was presented a reference portion of formula No. 1, and 6 unidentified (coded) portions of formula Nos. 1, 2, 3, 4, 5 and 6. The reference portion was given an arbitrary value of 7. The panel members were instructed to evaluate the flavor and consistency of each formula using a 10 point scale. After the first series of tests it was necessary to select more descriptive terms than consistency. Some panel members rated a formula lower than the reference formula because it was thin or watery, while others rated it lower because the product was thick or pasty. To correct this misunderstanding the terms "thin or watery" and "thick or pasty" were substituted for the single term "consistency." Portions of the guacamole products were rearranged and judged a second time. The tests were repeated three time on succeeding days. The mean scores together with an analysis of variance are reported in Table 2.

The addition of waxy rice flour paste and sodium alginate to guacamole reduced the watery separation which may occur upon thawing after storage at 0° F. without adversely affecting the flavor. Guacamole made by formula No. 6 received a mean score flavor rating of 5.8 (Table 2), which may mean that some taste panel members were able to detect the presence of 2.02 per cent waxy rice flour and 1.00 per cent sodium alginate. An analysis of variance, however, failed to show a significant difference in flavor attributable to differences in formula.

Watery separation was less in those guacamole products which had the higher percentage of sodium alginate. The addition of 3.02 per cent waxy rice flour without sodium alginate (formula No. 2) resulted in a product which was considered to be more watery than the control (formula No. 1). The water used in making the flour paste was not sufficiently bound in the mixture. The incorporation of 1.00 per cent sodium alginate (formula No. 6) resulted in a product which the sensory panel members considered to be slightly too thick and pasty, but the flavor was acceptable. Guacamole products prepared by either formula No. 4 or No. 5 were considered acceptable after 9 months frozen storage.

The experiments demonstrate that thickening agents such as waxy rice flour and sodium alginate may be incorporated in frozen guacamole formula to give acceptable products. Proportions of the thickening agents sufficient to reduce watery separation of the thawed guacamole may be added without any appreciable effect on flavor, and with the maintenance of good, if not actual improvement in the consistency of the product. The formulas tested, which incorporated thickening agents, increased the volume of the products by approximately 20 per cent. Incorporation of thickening agents in the formula for guacamole may permit the use of varieties and strains of avocados which would not otherwise be acceptable for a frozen guacamole product.

Table 2. Sensory evaluation of guacamole using waxy rice flour and sodium alginate as thickening agents.

Formula	*Flavor*	*Thin or Watery*	*Thick or Pasty*
1. No waxy rice flour No sodium alginate	6.8[1]	6.8[1]	6.8[1]
2. 3.02% waxy rice flour No sodium alginate	6.4	5.1	6.6
3. 2.77% waxy rice flour .25% sodium alginate	6.2	6.1	6.6
4. 2.52% waxy rice flour .50% sodium alginate	6.3	6.3	6.3
5. 2.27 waxy rice flour .75% sodium alginate	6.3	7.0	6.1
6. 2.02% waxy rice flour 1.00% sodium alginate	5.8	7.4	5.5
Least Significant Difference			
.01 level	1.6	.5	.4
.05 level	1.3	.4	.3

[1] These numbers represent numerical opinions of the judges. The word description of each number in the scale is:

1. Very poor	5. Acceptable	9. Excellent
2. Poor	6. Fairly good	10. Ideal
3. Fairly poor	7. Good	
4. Fair	8. Very good	

SUMMARY

The use of waxy rice flour and sodium alginate, a product derived from kelp, was investigated for use as thickening agents to reduce or prevent the watery separation of frozen guacamole, an avocado product, upon thawing for table use.

Waxy rice flour when used alone in high enough concentration to reduce watery separation, affected the flavor of the guacamole.

By using a combination of waxy rice flour and sodium alginate the proportion of waxy rice flour could be reduced so that the flavor of the guacamole was not significantly affected, the watery separation of the product was reduced, and its consistency was stabilized if not actually improved.

The waxy rice flour was folded into the mashed avocado flesh as a seasoned paste and in the formulas tested, resulted in a 20 per cent increase in product volume.

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VEGETABLE SECTION

The Future of Food Preservation

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One factor contributing to the development of man down through the ages has been his food supply. Very early, man devoted much of his time and energies to the search of food. Methods of preservation, other than naturally protected materials such as nuts and fruits dried on trees, were unknown to him. He lived a wandering life of feast or famine depending upon the season or luck of the hunt. With little time for other activities, he developed slowly. However, when man became a food producer, rather than a food gatherer, he had accumulated primitive preservation techniques such as salting, freezing and drying. He had time for certain humanistic pursuits and evolved into a civilized being. History has closely paralleled the development of man's food supply.

The preservation of foods, in their natural condition, has been a continuing goal of civilized man to the present. This has meant the control of numerous variables involving color, texture, shape, taste, odor, and nutrient value. The basic tools for the preservation of foods have been few. Reliance has been placed, for the most part, upon salt, sugar or water concentration, or changes in either pH or temperature. Application of these principles are continually being varied in an effort to preserve products and retain the appeal and nutrient value of natural foods at their peak of conditions or harvest.

The potential development and utilization of new techniques, materials, and forms of energy offers methods by which foods may be preserved without severe interference with their natural character. A few examples are: dehydro-freezing or dehydro-canning which are combinations of well-established techniques; the use of antibiotics, and the utilization of atomic energy in the form of ionizing radiations.

The economics of our food situation is such that there is an ever-increasing demand for larger quantities of attractive and nutritious foods. Every 12 seconds there is an additional consumer in the United States. During the 30 minutes allotted for these remarks there will be an additional 150 mouths to feed. Our population of 170 million is increasing at the rate of 1.8 per cent. Our total population will increase an additional 3 million in the next 12 months.

This brings to mind the old story told about one of the college deans who used to greet his incoming students with "Take a good look at the person on your right. Now take a look at the person on your left. By the end of this year one of you will be gone." Population-wise, within 20 years the converse of this will probably be true. At that time, there will be another person to join us. The population will be about one-third greater.

According to Mr. R. B. Reese, Agricultural Marketing Service of the U.S.D.A., acceptance of a food on today's market depends, in order of importance, upon three things: price, quality, and convenience. Food-buying trends by the housewife in recent years have demonstrated that she is willing to pay the price for high-quality food in a convenient form. Twenty years ago, about five hours were required by the housewife to prepare the daily meals from raw foods; today the average is down to 1.5 hours using partially prepared and ready to serve foods.

Among the methods of food preservation which hold promise for the future are: improvements in the technology of freezing and drying, combinations of freezing and drying, the use of antibiotics and similar materials, and the use of atomic energy in the form of ionizing radiations. The present status and the future outlook of the technology of these methods of preservation in brief would be as follows:

Freezing. At present there is need for a better understanding and control of temperatures during the storage and handling of frozen foods. This is particularly true at the retail and consumer level. A lack of technical information is not indicated; but rather a lack of dissemination. The possibility of food poisoning exists very strongly with frozen low-acid foods which are allowed to thaw and remain at warm temperatures for any length of time. Retail stores generally lack adequate bulk storage capacity and defrosting facilities. There has been a tendency toward overstocking frozen foods and building mass displays of frozen food packages without necessary cooling. The Western Regional Research Laboratory of the U.S.D.A., at Albany, California, recommends storage of frozen foods at 0° F. Perhaps the greatest need in this field is for an indicator which can be attached to or incorporated into the frozen food package which will indicate if the contents of the package have been allowed to thaw.

Drying. The technological advances of World War II have resulted in many highly acceptable dried or dehydrated foods. Among these are the many instant beverages, prepared cake mixes, and soups which we accept as a part of our diet today. Many problems still exist in the flavor and texture technology of certain dried foods. Consumers of C and K rations during World War II will readily attest to the fact that such problems existed then. The same people today are satisfied consumers of dried milk and other dehydrated products which have been improved or developed since World War II. Recent work reported by Dr. Max Brockman and his group at the Quartermaster Research and Container Institute indicate that the addition to dried foods of certain enzyme systems responsible for fresh flavor appears challenging. This group has also worked on the "Freeze-Drying" of foods, a method whereby water is evaporated from frozen foods under vacuum, utilizing the principle of sublimation. The Liana Company of Harlingen, Texas, is currently engaged in preserving shrimp in this manner.

An application of similar principles has resulted in the widely accepted frozen concentrated fruit juices which we have today. Moisture is removed from these foods by applying a vacuum which reduces the boiling point of the water and allows it to be driven off by mild heating which does not result in a "cooked" flavor. Upon reconstitution, then, the product resembles that of fresh fruit juice.

Combinations of Drying with Freezing or Canning. Recent work at the Western Regional Research Laboratory of the U.S.D.A. at Albany, California, and other agencies in this country have indicated that partially dehydrated foods can very successfully be handled as frozen or canned products. The deleterious effects of complete drying are avoided and the ease of preparing and serving frozen and canned foods is achieved. The economy of reduced weight is certainly desirable and these foods, particularly dehydro-frozen fruit products, have the additional advantage of being stable at higher storage temperatures.

There is a great need for technical information in this area relative to vitamin and nutrient losses, maturity of product to be handled, relative costs, and so forth.

Savings in shipping cost of foods in concentrated form, plus the economy and convenience to the consumer, indicate an increasing demand for this form of preserved food.

Antibiotics. The use of antibiotics as preservative agents has two major limitations. First, antibiotics are selective in their effect on spoilage organisms and are active primarily against bacteria. For the extension of storage life of fruits and vegetables the activities of molds must be controlled. Secondly, from the health safety standpoint of the consumer prolonged assimilation of even trace amounts of antibiotics is not recommended. This limits the use of antibiotics to heat labile forms applied to foods which must be cooked before consumption.

In spite of these limitations, there are areas where antibiotics are and can be used to good advantage. Currently they are widely used in cold water dips and incorporated in the packing ice for fresh fish and poultry. Such treatment extends the storage life of these foods many fold. The work of Dr. Hugh Tarr at the Fisheries Technical Station, Vancouver, British Columbia, indicates that wide use of antibiotics can be made particularly on fresh meats in sub-tropical areas which lack refrigeration facilities.

Atomic Energy. The utilization of atomic energy in the form of ionizing radiations for the preservation of food is a unique example of the development of a science preceding the development of the art. Many facts have been gathered and proven in this area of preservation but application has lagged somewhat due to lack of industrial know-how.

A great deal of enthusiasm was generated in this field of work with the recent availability of machines and radioactive isotope sources of powerful ionizing radiations. Many brash statements were made concerning the impact of this form of energy upon established methods of food preservation such as canning and cold storage. With the facts we now have, however, it is obvious that broad statements cannot be made and the availability of ionizing radiations will not revolutionize the food processing industry overnight.

Some of the problems associated with particular food components are:

1. The loss of carotinoids in tuna fish and fresh vegetables such as tomatoes.

2. Dextrins show color development at two million reps; the dosage necessary for destruction of *Clostridium botulinum* a resistant food-poisoning organism.

3. Starches degrade and become soluble upon irradiation.

4. Lipids oxidize in meats.

5. Wet proteins (in water carrier) develop increased solubilities and dry protein develops a decreased solubility.

It might be said in general that foods of a delicate nature develop flavor, color, odor, and texture problems upon irradiation.

Likely application of ionizing radiations in the near future will probably include the following:

1. Irradiation of Irish potatoes to inhibit *sprouting*. It has been estimated by Dr. Bruce Morgan, formerly of the Quartermaster Research and Container Institute, that 25% of the crop in excess of 61month-storage capacity could profitably be irradiated.

2. The destruction of *insect pests* in cereals, spices, and fresh fruits and vegetables. (Replace fumigation of certain foods.)

3. The eradication of *trichini* as a health hazard in fresh pork.

4. The *pasteurization,* rather than complete sterilization, of *fresh fruits and vegetables* to extend their shelf life under limited cold storage conditions.

In conclusion it should be pointed out that canning, pickling, smoking, and other methods of preservation have not been considered here. This is not because they will not continue to be important in the future, but rather that at the present time there does not appear to be any imminent revolutionary changes in the technology of these forms of preservation. We can be assured, however, that the steady progress of the past will continue and that the application of newer and more efficient techniques for food preservation will offer us a more varied, attractive, and nutritious diet of quality foods at an economical price, and in convenient form.

Uses of Gibberellic Acid

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Field testing of Gibberellic acid in the form of a commercial type formulation was only of a preliminary nature in the past year. Some possible uses in agriculture which developed were: lengthening of the inflorescence of the table grape so that at harvest the bunch was quite loose resulting in less shipping damage, increasing the size of celery at maturity, increasing the number of sprouts in potato and sweetpotato, replacing the chilling requirement in sugar beets and carrots so that seed harvest may occur earlier, and raising the height of such plants as spinach to eliminate soil damage to the lower leaves.

In Texas, tomatoes sprayed with Gibberellic acid set fruit earlier at Gibberellic acid rates of 5, 10 and 25 parts per million as an inflorescence or whole-plant spray. Adding 8 parts per million parachlorophenoxyacetic acid to the Gibberellic acid solutions further increased the early set. Some adverse effects were noted at rates higher than 25 parts per million. Style exertion occurred earlier, stems were extremely thin and broke easily, some pollen sterility was noted, and abnormal flowers occurred.

A formulated slurry material was tested on seeds. In general, seeds emerged earlier but no increase of stand was noted in seeds with high germination. A fungicide was required to prevent loss to damping-off diseases. In some cases, seed with poor germination as a result of long storage were revitalized to some extent. Disease problems with seed deteriorating under field conditions prevented an increase in stand.

The best seed treatment occurred at rates which stimulated emergence but did not result in a definite increase in height over the untreated seed. Some adverse effects on flowering and fruit development was noted at high rates of application. Optimum rates of application varied from vegetable to vegetable and also within a vegetable group.

Gibberellic acid appears to be a promising agricultural chemical and like other agricultural chemicals will have to undergo extensive testing in order to fit it into the agricultural picture.

Some New Pesticide Developments

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It is generally understood that an adequate food supply could not be produced without the aid of agricultural pesticides. As our agricultural programs become more and more intensive in nature our problems with respect to control of plant pests become more numerous and more serious. Consider for example the fact that certain insects are able to establish a degree of tolerance to applications of specific insecticides. The seriousness of this problem can only be fully appreciated when we realize that it is of national concern and involves several insecticides and several species of insects and mites.

To meet these problems and to help prevent the occurrence of new problems, members of the agricultural chemicals industry have increased their expenditures and efforts in the research and development area. Despite the fact that the cost of agricultural chemicals research has increased tremendously over the last few years, industrial research is going forward in a never-ending search for new and better pesticides.

As a result of a very active research program Niagara now has in various stages of development several new materials which show great promise as potential agricultural pesticides.

Niagara Tedion, 2,4,5,4'-tetrachlorodiphenyl sulfone is a miticide discovered in the laboratories of N. V. Philips-Roxane of the Netherlands for which the United States patent rights are controlled by the North American Philips Company.

The discovery of Tedion came at an opportune time when problems with respect to the control of mites had become increasingly serious. In many areas certain strains of mites have developed a high degree of tolerance to most of the established miticides and adequate control cannot be achieved.

As a result of several years of field testing in both the United States and Europe Tedion has been shown to possess very unique and promising acaricidal properties. It is relatively slow acting against adult mites yet it is a very effective ovicide and offers long residual control of newly hatched larvae and nymphs. In the laboratory, Tedion has demonstrated a mode of action extremely unique among pesticides. When adult female mites *Tetranychus telarius* (L.) were exposed to Tedion residues they were not readily killed and eggs which they later deposited either failed to hatch or were delayed in hatching far beyond the normal hatching period.

Tedion has given very effective control of mites on deciduous fruits, citrus and certain ornamentals. On citrus for example one pound of 25 per cent wettable powder per one hundred gallons of water has effectively controlled mites for periods in excess of ninety days. The same rate of application has given excellent mite control on roses both in the field and in the greenhouse.

Tedion is specifically a miticide and is primarily effective against tetranychid species. This degree of selectivity is obviously advantageous as it will allow predators to escape and further will not harm honeybees.

Tedion has been shown to possess a high degree of plant safety. No single case of phytotoxicity has been recorded to date, although many plant species have been treated and excessive dosage rates have been applied.

Toxicological studies with Tedion are still in progress and there is every indication that the material will prove to be very safe to warm blooded animals. The acute oral LD_{50} dosage rate for example is somewhat in excess of 15,000 mg/kg.

All of the evidence accumulated to date points to the fact that Tedion will certainly prove to be a very valuable addition to the list of available pesticides. Tedion will be available for certain uses in 1958.

Another Niagara material which will be available for certain uses in 1958 has been named Nialate. Nialate is a phosphate chemically identified as 0,0,0',0'-Tetraethyl-S,S'-methylene bisphosphorodithioate. Nialate, formerly known as Niagara 1240, was discovered and developed by the Niagara Research Department.

Nialate has been tested over a two-year period in most of the important crop areas of the U. S. by both state and federal research workers. Throughout the test period Nialate has demonstrated excellent acaricidal properties. Nialate functions as an ovicide, larvacide and adulticide offering good initial activity and for a phosphate comparatively long residual control. On cotton for example, one application of 0.25 pounds of Nialate per acre gave excellent control of the desert mite and two-spotted mite. Initial clean-up was sufficiently effective so as to prevent re-infestation for a period of approximately forty days.

Mite populations on citrus can be effectively controlled with Nialate and additionally preliminary tests indicate that Nialate combined with insecticidal oil may offer effective control of red and purple scale on citrus.

In addition to the fact that it is an excellent miticide Nialate will afford control of several species of insects such as Mexican bean beetle, pickle worm, spinach leaf miner, serpentine leaf miner, lygus, onion maggot and many others not of particular importance in this state.

Nialate will be available for use on cotton in 1958. Toxicology and residue studies should be completed so that it will be available for use on citrus and many other crops in 1959.

Niagara Thiodan is another new material being developed currently which offers promise of becoming a very important pesticide. Thiodan identified as hexachloro-hexahydro-methano-2,4,3-benzodioxathiepin oxide was discovered in the laboratories of Farbwerke Hoechst AG., Frankfurt, Germany. Under the guidance of Niagara, Thiodan has been tested widely throughout the U. S. by state and federal investigators.

Thiodan has a very broad spectrum of activity as indicated by the fact that it will control all or most of the insect pests on cotton, tobacco, potatoes and forage. It will control certain pests on deciduous fruits and vegetables and will effectively control most ant species. Thiodan is a very effective aphicide offering excellent control of many species.

With respect to phytotoxicity Thiodan has been reported to injure grapes at 1.5 pounds of wettable powder per 100 gallons and also to injure young corn at 1.5 pounds actual toxicant per acre. No other cases of injury have been reported despite wide scale usage in experimental plots.

Thiodan will be offered for sale for use on potatoes and possiblv cotton in 1958.

Several other new materials are in the laboratory stages of a development program. While they are too new to merit discussion at this time, it is sufficient to point out that this group of materials includes candidates for a post-emergent herbicide for use on cotton, a post-emergent herbicide for use on vegetables, a new nematocide and a new fungicide for general use.

In summary, it is apparent that the intensive nature of our agricultural programs is responsible for the creation of many new problems with respect to the control of plant pests. Industry in general and Niagara in particular has recognized the need for more active research programs and as a result new and improved pesticides are available to cope with new problem situations.

Notes on the Control of the Tropical Mite Attacking Tomatoes

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During the past two years the mite, *Tetranychus marianae* McG., locally known as tropical mite, has become the most important pest of tomatoes in the Lower Rio Grande Valley (Wene 1956). Many growers unaware of the presence of this mite in their fields had their tomato plants destroyed even before a single tomato was picked. Furthermore those growers aware of the presence of this pest spent a considerable amount of money in order to minimize the destructiveness of this mite.

The tropical mite has also been found in destructive numbers on eggplant and potatoes. As mentioned by Wene (1957), night-shade is the preferred host.

Observations indicate that the tropical mite is a dry weather pest. By the end of May mites averaged over 200 per tomato leaf in the McAllen area. Light showers fell for 3 days and after that the population was reduced to about 10 individuals per leaf. On June 18 large populations of the tropical mite were observed on night-shade. During the following week light intermittent showers fell, and the tropical mite population dropped to only 2 or 3 per leaf. These and other observations indicate that the tropical mite is directly affected by prevailing weather conditions.

Demeton and trithion, applied as sprays, gave good control of the tropical mite (Wene, 1957). Two experiments were conducted in order to evaluate some of the recent miticides.

PROCEDURE

Rotary hand dusters were used in applying miticides dusts at the rate of 30 pounds per acre to maturing tomato plants. Each treatment plot was 0.03 acre in size, and each treatment was replicated three times.

Each treatment plot in the spray experiment consisted of two rows of tomatoes 30 feet in length. The rows were spaced 40 inches apart and an untreated row was left between treatment plots. Each treatment was replicated 3 times. The miticides were applied with a three-gallon garden sprayer at the rate of 100 gallons per acre.

The efficiency of each treatment was determined by selecting 10 plants at random in each plot and counting the number of live mites at various time intervals after application.

RESULTS

The data in table 1 show a reduction in the mite population in the untreated plot which was due to light rains that fell on the third and fourth day after treatment application; however some trends on the effectiveness of the various insecticides were apparent.

The data in table 1 show that the best control 1-day after treatment application was obtained with 4 per cent Mitox or 1 per cent TEPP. It is interesting to note that the TEPP dust injured the new tomato growth only slightly, even though it was applied in the presence of a heavy dew. A 4 per cent trithion dust gave 62 per cent control but this dust was the only insecticide tested that showed good residual control. Phosdrin, at 1 per cent concentration was as effective as the Trithion treatment immediately after the treatment application but rapidly lost its effectiveness. The combination of malathion with parathion did not give economical control.

The data in table 2 show that chlorobenzilate gave excellent control

Table 1. Control of the tropical mite on tomatoes with various insecticidal dusts.

	1 Day After		*6 Days After*	
Treatment	*No. per leaf*	*Percent control*	*No. per leaf*	*Percent control*
4% Miltox	40	76	15	25
4% Malathion + 2 Parathion	61	50	10	50
1% TEPP	39	76	11	45
4% Trithion	47	62	4	80
1% Phosdrin	46	62	18	10
Untreated	123	....	20*	....

* Reduction in population due to light rains on the third and fourth day after treatment application.

Table 2. Control of the tropical mite with various insecticides applied as high volume sprays.

	Mite Population 3 Days After	
Amount toxicant per 100 gallons water	*No. per leaf*	*Percent control*
0.5 Lb. Chlorobenzilate	8	95
0.5 Lb. Kelthane	67	54
0.8 Lb. Mitox	57	61
0.5 Lb. Diaszinon	23	84
Untreated	147	

of the mite. Diaszinon showed promise and should be investigated further. The data also show that Kethane and Mitox, at the dosage used, were not effective enough for commercial control.

SUMMARY

Good control of the tropical mite was obtained with a Trithion dust and spray formulation of chlorobenzilate and Diaszinon. Effective control was not obtained with Mitox, TEPP, Phosdrin, and Kelthane.

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Effectiveness of Various Insecticides in Controlling the Corn Earworm

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In recent years some insects have developed resistance to certain insecticides. It therefore seemed desirable to determine whether the corn earworm, *Heliothis zea,* could be controlled effectively by insecticides other than the DDT treatment now used.

Each experimental plot consisted of a single 40-foot row of the sweet corn hybrid, Calumet. Each treatment and check was replicated four times. The stencil brush method was used in applying the insecticidal dusts. This consisted of dipping a 2" paint stencil brush in the insecticide and then pressing the brush into the silk mass of each ear (Wene 1957). Three treatments were applied at three-day intervals; the first being made when 10% of the sweet corn plants were silking. Twelve days after the final application of insecticide, 15 ears were selected at random from each plot and the percentage of worm-free ears determined.

DISCUSSION OF RESULTS

The first experiment was conducted in the fall of 1955. Although the data show a high percentage of infested ears, the corn earworm infestation was classified as light because most of the damage in the untreated plots was confined to the terminal 0.5 inch of the ear tip. The data showed that 20% toxaphene and 2% endrin dusts were as effective as DDT in controlling the corn earworm. Dust applications of 1% Guthion, 2% phosdrin, and a mixture of 0.9% piperonyl butoxide with 0.06% pyrethins failed to give effective control of the corn earworm.

Table 1. Toxicity of various insecticides against the corn earworm when applied as a dust with a stencil brush.

Insecticides	*% Worm-free Ears*
Experiment 1, 1955	
0.9% Piperonyl butoxide + 0.06% pyrethrins	15
1 % Guthion	58
2 % Phosdrin	45
2 % Endrin	93
20% Toxaphene	85
10% DDT	85
Untreated	8
Experiment 2, 1957	
5 % Perthane	79
5 % Sevin	97
4 % Trithion	85
50% Calcium Arsenate + 50% sulphur	50
10% DDT	83
Untreated	23

In 1957 the experiment was conducted during the spring sweet-corn growing season. The corn earworm infestation was unusually severe, as most of the ears showed more than one inch of earworm injury on the ear tips. Applications of 10% DDT dust resulted in 83% worm-free ears. A 5% Sevin dust was more effective than the recommended DDT and warrants further investigation. Trithion, at 4% was as effective as the DDT and should also be investigated further since it is different chemically than DDT. Perthane, at 5% is very similar to DDT chemically, and was found to be almost as effective as DDT. The data in Table 1 show that calcium arsenate only gave partial control of the corn earworm.

SUMMARY

Good control of the corn earworm was obtained with Endrin, toxaphene, DDT, Perthane, Sevin and Trithion when applied three times, at three-day intervals with a stencil brush. Guthion, Phosdrin, Calcium arsenate and a mixture of piperonyl butoxide with pyrethrins failed to control the corn earworm.

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TDE Residues on Tomatoes and Spinach

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TDE is used extensively on tomatoes for the control of the tomato fruitworm. Occasionally, TDE is applied also to spinach for the control of other vegetable insects. Since TDE has a tolerance of 7 ppm on edible crops, two experiments were conducted to determine the amount of TDE remaining on tomatoes and spinach at various time intervals after treatment application.

PROCEDURE

In the tomato experiment a one-tenth-acre plot was hand-dusted with 5% TDE at 26 pounds per acre. At 2, 4, and 6 days after treatment 12 one-pound samples of tomatoes were picked at random from the treated plot. Another 12 one-pound samples were selected from an untreated plot located 300 feet away. Half of the treated and the untreated tomato samples were washed. Then all the samples were air expressed to the Rohn & Haas Co. laboratories for residue analysis.

The spinach plots were also one-tenth of an acre in size with a distance of 100 feet separating the plots. One plot was hand dusted with 10% TDE at 25 pounds per acre. The other plot was sprayed at the rate of 2 pounds of TDE per acre in 4.5 gallons of water. At 3, 5 and 7 days after treatment 6 one-pound samples of spinach were harvested at random from each plot. A similar numbers of samples was taken from an untreated area. These samples were then air expressed to the Rohm & Haas Company Laboratories for residue analysis.

RESULTS

The data in Table 1 show that very little TDE residues remains on tomatoes even 2 days after treatment. The data show that washing reduced the amount of TDE residue slightly. All residues found were below the 7 ppm tolerance.

Table 1. TDE residues, ppm, found on tomatoes 2, 4 and 6 days after application.

Treatment 26 lbs. of 5% TDE	*TDE Residues on Tomatoes after 2 Days*	*4 Days*	*6 Days*
	p.p.m.	*p.p.m.*	*p.p.m.*
Unwashed	0.63	0.31	0.40
Washed	0.39	0.23	0.00

Table 2. TDE residues, ppm, found on spinach 3, 5 and 7 days after application.

Treatments	*TDE Residues on Spinach after 3 Days*	*5 Days*	*7 Days*
	p.p.m.	*p.p.m.*	*p.p.m.*
2.5 lbs. Dust*	115.0	15.6	5.4
2.0 lbs. Spray	192.0	15.8	6.9

* 25 pounds of a 10% dust

The data from the spinach plots show that a considerable amount of TDE was adherring to the spinach 3 days after the treatment (Table 2). The data taken 5 and 7 days after the treatment indicate that the "decay curve" for TDE is extremely steep. The data indicate that TDE sprays adhere more than dusts. Seven days after treatment the TDE residues from both the dust and spray application were below the 7 ppm tolerance.

SUMMARY

Residue analysis show that 0.63 ppm of TDE was found on tomatoes 2 days after treatment. Data taken from spinach show that 5 days after treatment the residues were above the 7 ppm tolerance but were below the tolerance on the seventh day.

Toxaphene Residues on Certain Vegetables at Various Time Intervals After Application

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Recently there has developed a great concern about the amount of residues remaining on vegetables after applying insecticides. Since toxaphene is used very extensively in the Lower Rio Grande Valley residues were studied on six vegetables grown in that area.

PROCEDURES

The treatment plots in all experiments, except that shown in Table 4, were single plots 0.1 acre in size. The cabbage treatment plots were 0.02 acre in size with each treatment being replicated three times.

Toxaphene was applied as a dust to all vegetables except onions. The dusts were applied with a rotary hand duster and the amounts applied per acre is expressed as actual amount of toxaphene per acre, whether applied as a 10% or 20% dust. Toxaphene was applied as a low volume spray (4.5 gallons per acre) to onions and also to cabbage. The amounts of toxaphene applied are shown in the accompanying tables.

Certain plots received two or three applications, applied at 7-day intervals. Since commercial growers usually apply more than one insecticidal application for vegetables other than canning beans, a maximum of three applications was applied to the treated vegetable crops except beans, which received a single application.

Samples for residue analysis of all the vegetables except cabbage were usually two or more pounds in weight. Immediately after harvesting, the samples were frozen and shipped in containers with dry ice to the Hercules Powder Company Laboratories for residue analysis. The cabbage samples, three heads from each plot, were placed in basket containers and air-expressed to the same company for analysis.

DISCUSSION OF RESULTS

Canning beans: Canning beans very seldom require the application of an insecticide, but to control an occasional infestation of army worms or stink bugs one or more applications are necessary. The amount of toxaphene residue was found to be small within three hours after application, especially when the beans were washed (Table 1). One week after the treatment applications the residue found on beans was small even in those plots dusted at the rate of 5 pounds actual toxaphene per acre. The small amount of residues are explained in part by the fact

that the beans were well protected by foliage and were not directly exposed to the insecticide.

Lettuce: In harvesting lettuce the outside wrapper leaves, which receive most of the insecticide applied, are discarded. The toxaphene residues ranged from 0.5 to 1.7 ppm 7 days after the last application and 0.2 to 0.9 ppm one week later (Table 2). Since the sample with three applications showed a residue value of 0.5 ppm, it appears that a contamination or sampling problem occurred in the sample that received only two applications and averaged a residue value of 13 ppm.

Bell Peppers: In order to grow bell peppers successfully, two or three applications of insecticides are required for the control of various insects. Toxaphene residues on bell peppers were very low (Table 3) even from those samples taken one hour after treatment application. Immediately after application, large quantities of dust was visible on the pepper leaves and little or no dust could be seen on the fruit, indicating that the slick surface of the fruit was not conducive to dust adherence, which in turn explains the low residues found on the fruit.

Cabbage: The outer leaves, which receive most of the insecticide during application, are discarded during the harvesting process. So only a small amount of insecticide is deposited on the edible portion of the head. The toxaphene residues were small one week after application (Table 4). Two weeks after application the residues remaining were nil.

Table 1. Toxaphene residues, ppm, found on string beans at various time intervals after a single dust application.

Processing	Toxaphene per acre	Toxaphene residues on string beans after 3 hrs.	1 wk.	2 wks.	3 wks.
	Pounds	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Unwashed	2.5	3.2	0.5	0	0.1
Washed	2.5	2.6	0.6	0.4	0.3
Unwashed	5.0	11.7	1.3	0.2	0.3
Washed	5.0	2.7	1.1	0.3	0.3

Table 2. Toxaphene residues, ppm, found on lettuce at various time intervals after the last dust application.

Applications Number	Pounds/A.	Toxaphene residues after 1 wk.	2 wks.	3 wks.
		p.p.m.	p.p.m.	p.p.m.
1	2.2	1.7	0.9	0
2	2.2; 3.3	13.0	0.2	..
3	2.3; 3.3; 2.2	0.5	....	..

There was very little difference between the amount of residues from the toxaphene spray or dust application.

Table 3. Toxaphene residues, ppm, found on bell peppers at various time intervals after the last dust application.

Processing	Applications*		Toxaphene Residues after last applications				
			1 hr.	1 wk.	2 wks.	3 wks.	4 wks.
	Number	Pounds/A.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Unwashed	1	2.5	....	....	0.2	0.2	0.8
	2	2.5; 2.5	1.0	....	0.9	0.4	....
	3	2.5; 2.5; 2.5	....	2.3	1.0	....	....
Washed	1	2.5	....	0.1	0.3	0.4	0.8
	2	2.5; 2.5	0.5	0.5	0.7	0.6	....
	3	2.5; 2.5; 2.5	....	2.6	0.8	....	....
Unwashed	1	5	....	0.8	1.0	1.0	0.7
	2	5; 5	2.9	3.4	2.1	1.8	....
	3	5; 5; 5	....	2.8	1.6	....	....
Washed	1	5	....	1.0	0.2	0.7	0.4
	2	5; 5	1.0	1.1	1.6	1.0	....
	3	5; 5; 5	....	1.5	1.3	....	....

* applied at 7 day intervals

Table 4. Toxaphene residues, ppm, found on cabbage at various time intervals after applications of dusts and sprays.

Toxaphene Formulation	Applications*		Toxaphene residues after last application		
			1 wk.	2 wks.	3 wks.
	Number	Pounds/A.	p.p.m.	p.p.m.	p.p.m.
Dust	1	2.2	0.3	0.1	0.1
	2	2.2; 1.	0	0.3	....
	3	2.2; 1.5; 1.5	0.2	....	....
Spray	1	2.2	0	0	0.1
	2	2.2; 1.5	0.1	0	....
	3	2.2; 1.5; 1.5	1.3	0.1	....
Dust	1	3.6	1.3	0	0.2
	2	3.6; 4	0	0.3	....
	3	3.6; 4; 4	1.3	....	....
Spray	1	3.6	5.6	0	0.1
	2	3.6; 4	0	0.2	....
	3	3.6; 4; 4	0.8	....	....

* applied at 7 day intervals

Onions: To control onion thrips a low volume spray was applied in practically all the fields. In the sprayed plots the onion tops retained a large amount of toxaphene residues for a period of three weeks (Table 5). At the rate on 1.5 pounds per acre the toxaphene residues on onion bulbs were negligible one week after application while with the rate of 3 pounds per acre, the residues were much greater. Two weeks after application the residues had decreased greatly, indicating that toxaphene may be applied within two weeks of harvest.

Beets: Beet tops (leaves) retained large amounts of toxaphene residues for 14 days after treatment application (Table 6). The beet roots also retained large amounts of toxaphene residues. The beets were dusted during a period when excessive dews prevailed. These dews washed the toxaphene dust to the bottom of the plants and since half of the beet root grows above ground it could be easily become contaminated. To test this theory, another plot of beets was dusted at the rate of three pounds of toxaphene per acre. Six days after the application, a sample of beet roots was taken. These roots were peeled before the toxaphene residue analysis was made. The analysis showed only 0.1 ppm of toxaphene residues. These additional data indicate that more residue work on beets is desirable.

SUMMARY

Small plots of vegetables were either dusted or sprayed with toxaphene. At stated intervals after applications, samples were analyzed for the amount of toxaphene residues persisting.

Very small amounts of toxaphene residues were found on canning beans and peppers within a few hours after application.

Table 5. Toxaphene residues, ppm, found on onions at various time intervals after spray applications.

Applications*		Toxaphene residues after application					
		Tops			Bulbs		
		1 wk.	2 wks.	3 wks.	1 wk.	2 wks.	3 wks.
Number	Pounds/A.	p.p.m.					
1	1.5	15.0	6.1	5.0	1.6	0.3	0.1
2	1.5; 1.5	31.0	14.0	....	1.8	4.5	....
3	1.5; 1.5; 1.5	34.0	....	....	0.5	....	....
1	3	71.0	26.0	10.0	4.6	0.4	2.1
2	3; 3	54.0	23.0	....	1.3	1.4	....
3	3; 3; 3	47.0	....	....	3.4	....	....

* applied at 7 day intervals

Table 6. Toxaphene residues, ppm, found on beets at various time intervals after dust applications.

Applications			Toxaphene residue, days after application 7	12	14	19
Number	Pounds/A	Beet Tops	p.p.m.	p.p.m.	p.p.m.	p.p.m.
1	1.5		38.0	....	14.5	4.3
2	1.5; 1.5		26.9	19.5	....	....
3	1.5; 1.5; 1.5		24.5	....	....	....
1	3		32.0	....	10.4	5.5
2	3; 3		35.0	26.3	....	....
3	3; 3		41.1	....	....	....
		Beet Roots				
1	1.5		3.9	....	7.0	3.3
2	1.5; 1.5		14.2	3.8	....	....
3	1.5; 1.5; 1.5		9.7	....	....	....
1	3		3.3	....	4.7	4.2
2	3; 3		15.9	12.4	....	....
3	3; 3; 3		12.2	....	....	....

One week after application only small amounts of toxaphene were found on cabbage and lettuce.

Large amounts of toxaphene residues persisted on onion tops three weeks after spraying.

Two weeks after the application the toxaphene residues had almost disappeared from the onion bulbs.

Large amount of toxaphene residues were found to persist on beet leaves and roots.

Cabbage Looper Control Experiments During 1956

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During the fall of 1956 growers reported that cabbage loopers were difficult to control. Three experiments were conducted in order to determine if the recommended insecticides were failing and also to evaluate recently-developed insecticides for control of the cabbage looper.

PROCEDURE

Treatments in the first two experiments were applied as high volume sprays at the rate of 100 gallons per acre. The insecticide concentrations used are shown in Tables 1 and 2. Each treatment plot consisted of a single row of mature cabbage, 30 feet in length. An untreated cabbage row was between each plot. All spray treatments were replicated three times.

Each of the dust treatment plots in the experiment was 0.02 acres in size. Each dust treatment was replicated three times. The insecticidal dusts, shown in Table 3, were applied with rotary hand dusters at approximately 25 pounds per acre. The cabbage in this experiment was also mature.

DISCUSSION AND RESULTS

Control of severe cabbage looper infestations, averaging one or more loopers per plant, is very difficult especially when the cabbage is in an advanced stage of growth. Experiments over the past eight years have shown that 70 per cent control is usually all that can be expected from treatments applied to a field severely infested with the cabbage looper.

Since the cabbage was mature, approximately 100 gallons of spray was required to give complete coverage. The data show that toxaphene, at the rate used, failed to give satisfactory looper control. Parathion, methyl parathion, endrin and phosdrin gave excellent control (Tables 1 and 2). Methyl parathion gave a higher initial kill of cabbage loopers than did parathion (ethyl) (Table 1). Trithion at 1 lb., malathion at 1.2 pounds and Sevin at 0.5 pound gave commercial control and should be investigated further at higher dosage rates. Malathion at 0.6 pounds and Perthane at 1 pound per 100 gallons of water failed to give commercial control of the cabbage loopers.

Additions of organic phosphates to chlorinated-hydrocarbon insecticide resulted in excellent looper control. An improvement in control of the insect was obtained when either methyl or ethyl parathion was added to toxaphene and when malathion was added to Perthane.

In the dust experiment, shown in Table 3, the addition of 2.5 per cent concentrations of either parathion (ethyl) or methyl parathion increased the effectiveness of the 20 per cent toxaphene dust in controlling cabbage loopers.

Table 1. Control of cabbage loopers with high volume sprays (Fall, 1956).

Amount Insecticide per 100 Gal. water	Cabbage Looper Control After: 1 day	6 days
	Percent	Percent
1.5 lbs. Toxaphene	54	58
1.5 lbs. Toxaphene + 0.25 lb. Methyl Parathion	84	98
1.5 lbs. Toxaphene + 0.25 lb. Parathion	73	98
0.25 lb. Methyl Parathion	85	90
0.5 lb. Methyl Parathion	89	96
0.25 lb. Parathion	58	90
0.5 lb. Parathion	85	90
0.4 lb. Endrin	85	90
Untreated	*	**

*Untreated plots averaged 4.8 cabbage loopers per plant
**Untreated plots averaged 5.0 cabbage loopers per plant

Table 2. Control of cabbage loopers with high volume sprays (Fall, 1956).

Amount Insecticide per 100 Gal. water	Cabbage Looper Control After: 1 day	6 days
	Percent	Percent
0.5 lb. Trithion	35	44
1.0 lb. Trithion	71	75
0.6 lb. Malathion	59	63
1.2 lbs. Malathion	71	69
1.0 lb. Perthane	59	56
1.0 lb. Perthane + 0.6 lb. Malathion	94	88
0.5 lb. Sevin	59	69
0.25 lb. Phosdrin	94	100
Untreated	*	**

*Untreated plots averaged cabbage loopers per plant
**Untreated plots averaged 1.6 cabbage loopers per plant

Table 3. Control of Cabbage Loopers with various insecticidal dust formulations (1956).

Insecticide (Dusts, 25# per Acre)	Looper Control After: 1 day	7 days
	Percent	Percent
20% Toxaphene + 2.5% Methyl Parathion	81	94
20% Toxaphene + 2.5% Parathion	72	91
20% Toxaphene	47	66
Untreated	6	**

*Untreated plots averaged 6.9 cabbage loopers per plant
**Untreated plots average 3.5 cabbage loopers per plant

SUMMARY

Toxaphene, either as a dust or spray, failed to give commercial control, but the additions of either parathion or methyl parathion increased the control obtained. Commercial control was also obtained with trithion, parathion, methyl parathion, endrin, phosdrin, malathion, Sevin, and a mixture of Perthane and malathion.

The Yield, Head Weight and Head Size of Cabbage As Affected By Different Fertilizer Treatments

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INTRODUCTION

Cabbage production in the Lower Rio Grande Valley first assumed commercial importance in the early years of the twentieth century and today is a major crop of the winter vegetable industry in the area.

The annual production of winter cabbage in the United States is approximately 346,500 tons. Texas produces about one-third of this total or 120,000 tons per year. More than 90 per cent of the total winter cabbage production in Texas is grown in the Lower Rio Grande Valley. Commercial acreage planted to cabbage in Texas is about 25,000 acres, most of which is in the Lower Rio Grande Valley. The crop has an annual value of almost 3 million dollars. Average yields for the States as a whole are low, being about 4.4 tons per acre (Friend).

In view of the importance of cabbage to the winter vegetable industry of the Valley and because of the low average yields per acre, considerable research has been conducted toward the development of practices to enable growers to more efficiently produce this important crop.

Research results with commercial fertilizers have shown that yields may be increased two to threefold with proper fertilization. Fertilization has also been found to improve the quality of cabbage. Results of this research has been previously reported (Burleson et al, 1950; Cowley et al, 1949; Morris et al, 1949; Morris, 1950).

This paper presents results of a cabbage fertilizer experiment conducted cooperatively by Rio Farms, Inc. and the Lower Rio Grande Valley Experiment Station during the 1955-56 season. The data presented further substantiate results obtained in previous investigations.

METHODS AND MATERIALS

The experiment was conducted on an irrigated Hidalgo loam soil on land furnished by Rio Farms, Inc. near Monte Alto, Texas. Results of soil tests by the Texas Agricultural Extension Service Soil Testing Laboratory on top soil from the experimental area were as follows: pH–8.0,, organic matter–1.64%, P_2O_5–68 p.p.m., K_2O–over 240 p.p.m. and CaO–over 2800 p.p.m.

Fertilizer treatments included 0, 60, 120 and 180 pounds of nitrogen (N); 0, 60 and 120 pounds of phosphoric acid (P_2O_5); and 0 and 60 pounds of potash (K_2O). These materials were used alone and in all possible combinations making a total of 24 different fertilizer treatments.

Nitrogen was from ammonium nitrate (33% N), phosphoric acid from super-phosphate (45% P_2O_5) and potash from muriate of potash (60% K_2O).

Fertilizer materials were applied in the center of the beds 3 to 4 inches below the seed zone. All of the phosphoric acid and potash was applied before planting. Only 60 pounds of nitrogen of any treatment were applied before planting, and the remaining nitrogen to complete the treatments was sidedressed 60 days after planting. Cabbage of the variety Glory of Enkhuizen was seeded two rows on each bed the first of November. The cabbage plants were thinned to a 14 inch spacing in the row.

The test design was a 4x3x2 complete factorial with three replications. Each plot consisted of four double rows 50 feet long. The two middle rows of each plot were harvested for yield data.

The plots were harvested on February 28, March 7 and March 16. The cabbage was graded and sized by hand in the field at time of harvest. The marketable cabbage was further classified as to size based on the following size classifications:

Small: Too small for crate cabbage, usually under 1.5 pounds per head and less than 5 inches in diameter.

Medium: Desirable size for crate cabbage. Head weight ranging from 1.75-2.75 pounds per head and from 5 to 6 inches in diameter.

Large: Too large for crate cabbage. Usually 3.0 pounds or more per head and over 6 inches in diameter.

RESULTS AND DISCUSSION

Significant increases in the yield of marketable cabbage were obtained from applications of fertilizers. The effect of fertilizer treatment on the head size distribution and total yield of marketable cabbage is shown in Table 1. Nitrogen alone accounted for most of the increase in yields with an increase from 7.4 tons per acre without fertilizer to 16.8 tons per acre from the application of 180 pounds of nitrogen per acre. The highest average total yield of marketable cabbage was 19.1 tons per acre from a fertilizer treatment of 180 pounds of nitrogen and 120 pounds of phosphoric acid. The effect of nitrogen on total yields of marketable cabbage is shown in Figure 1.

The size of heads was also affected by fertilizer treatment. Figure 2 demonstrates how head size distribution was affected by different amounts of nitrogen. It is obvious that without the use of nitrogen the majority of cabbage produced was small in size, whereas with increasing amounts of nitrogen the yield of medium size cabbage continued to increase and the yield of the small size decreased. The yield of the large heads of cabbage was not greatly increased by increasing amounts of nitrogen. The high density stand apparently prevented excessive growth and production of large heads which are not desirable for the fresh cabbage market.

The effect of phosphoric acid on head size distribution is shown in Figure 3. Applications of phosphoric acid, similar to applications of nitrogen, significantly increased the yield of the medium size heads of cabbage with a subsequent decrease in the small sizes.

Combinations of nitrogen and phosphoric acid resulted in both high-

Table 1. Effects of fertilizer treatments on the head size distribution and average total yield of marketable cabbage.

Total nutrients in fertilizer, pounds per acre			*Yield and size distribution of marketable cabbage, tons/acre*			
N	*P_2O_5*	*K_2O*	*Small*	*Medium*	*Large*	*Total*
0	0	0	6.4	1.0	.0	7.4
0	0	60	6.5	1.7	.0	8.2
0	60	0	6.6	3.6	.0	10.2
0	60	60	5.7	2.3	.0	8.0
0	120	0	7.3	1.4	.0	8.7
0	120	60	5.4	.9	.0	6.3
60	0	0	7.4	3.1	.0	10.5
60	0	60	7.9	5.2	.0	13.1
60	60	0	6.7	8.5	.6	15.8
60	60	60	7.0	7.5	.1	14.6
60	120	0	5.5	9.7	.3	15.5
60	120	60	8.1	7.9	.3	16.3
120	0	0	8.1	6.9	.0	15.0
120	0	60	8.0	8.4	.3	16.7
120	60	0	6.7	8.0	.7	15.4
120	60	60	5.5	10.7	1.0	17.2
120	120	0	5.6	9.2	2.4	17.2
120	120	60	6.9	10.0	.9	17.8
180	0	0	8.3	8.4	.1	16.8
180	0	60	7.5	8.9	.2	16.6
180	60	0	4.8	10.3	1.3	16.4
180	60	60	5.1	9.7	1.3	16.1
180	120	0	5.8	12.0	1.3	19.1
180	120	60	5.0	12.6	1.3	18.9

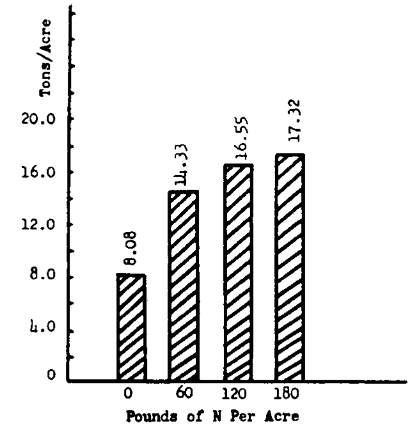

Figure 1. Main Effect of Nitrogen on the Yield of Marketable Cabbage

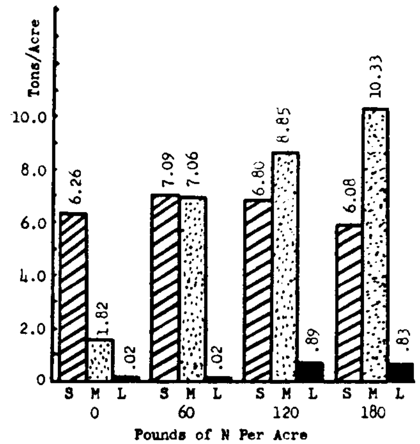

Figure 2. Main Effect of Nitrogen on Head Size Distribution of Marketable Cabbage

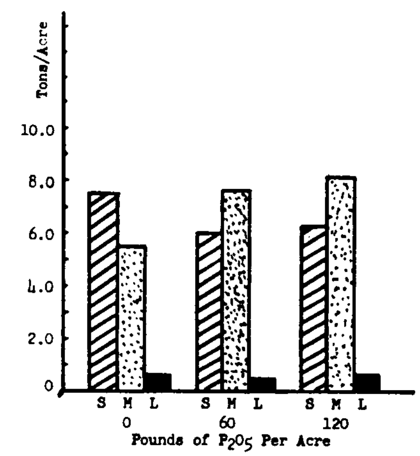

Figure 3. Main Effect of Phosphoric Acid on Head Size Distribution of Marketable Cabbage

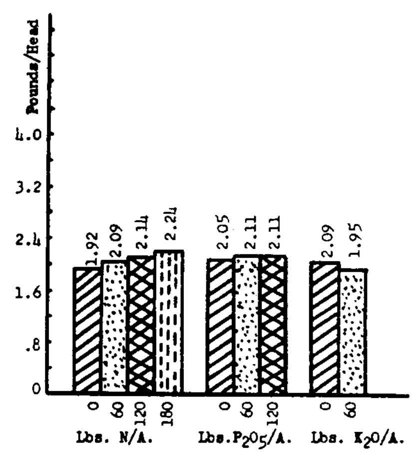

Figure 4. Main Effect of N, P and K on the Head Weight of Medium Size Cabbage

er total yields and yield of medium sized cabbage than either nitrogen or phosphoric acid alone. This is shown best by the following comparisons showing the tons per acre of cabbage:

Fertilizer Combination	*Medium size*	*Total yield*
Without either nitrogen or phosphoric acid	1.0	7.4
With 60 pounds of phosphoric acid, no nitrogen	3.6	10.2
With 60 pounds of nitrogen, no phosphoric acid	3.1	10.5
With 60 pounds each of nitrogen and phosphoric acid	8.5	15.8

Further similar comparisons may be made from yield data given in Table 1.

The effect of individual fertilizer constituents on the average head weight of medium size cabbage is shown in Figure 4. Both nitrogen and phosphoric acid tended to increase the average head weight whereas potash appeared to cause a decrease in head weight.

SUMMARY

The yield of cabbage was increased from 7.4 tons per acre without nitrogen to 10.5, 15.0 and 16.8 tons per acre respectively with 60, 120 and 180 pounds of nitrogen per acre.

Nitrogen and phosphoric acid alone and in combination resulted in an increase in the yield of medium size cabbage and a reduction in the yield of small sizes.

Average head weights were slightly increased from both nitrogen and phosphoric acid treatments, whereas potash applications caused a slight decrease in average head weight.

The highest total yield (19.1 tons per acre) was from a combination of 180 pounds of nitrogen and 120 pounds of phosphoric acid.

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Seasonal Production of Carrots in Texas and Competing States

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Carrot consumption has increased very rapidly during the last 25 years due to the publicity given to their high dietary value, particularly as a source of vitamin A. During the last few years, packaging in film bags has further increased their popularity.

This increased popularity of carrots has not, however: resulted in an increased total production of carrots from the three leading carrot-producing states, California, Texas, and Arizona during the period 1952 to 1956 (Figure 1). Texas, the second ranking state, increased shipments where as the other two states showed steady decreases. If this present trend continues Texas will within the next three to five years become the leading carrot-producing state in the country.

The high rank which Texas holds in carrot production is a result of the large acreage planted rather than to high yields per acre. For the period 1949-55 the average yield per acre for the respective states was: California 22,300 pounds, Arizona 18,700 pounds, and Texas 8,700

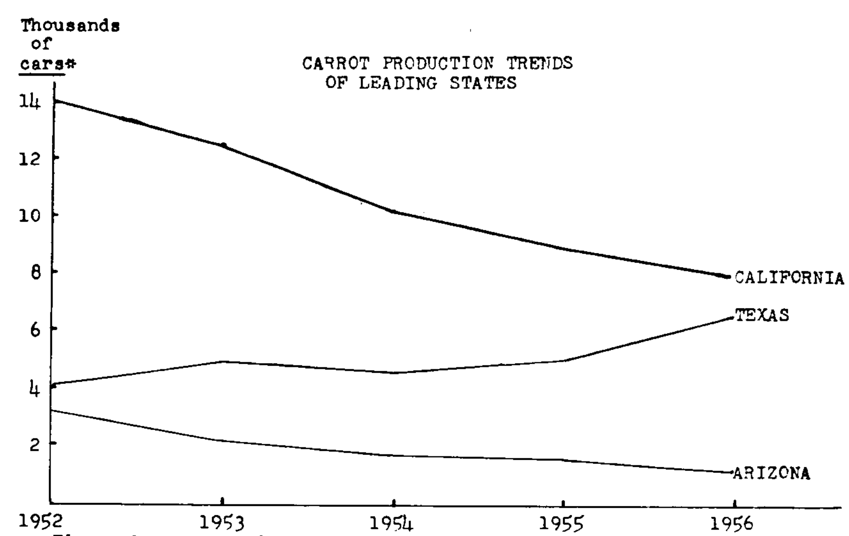

Figure 1 . Comparison of carrot production trends in Arizona, California, and Texas.
* Thousands of cars per year of rail shipments.
Source of data: Anon(1953-1957).

pounds. During the same period the respective acreages were California 9,260, Arizona 2,640, and Texas 27,790 (Winfrey 1953-1957). According to Friend (1955) the low average yields of marketable Texas carrots is largely due to heavy field culling of undersized roots and malformed roots due to excessive crowding. This excessive crowding is related to uneven spacing of seed within the row and to the absence of hand-thinning practices, sometimes used in other areas.

The relationship of volume of shipments and price directly affects the prices received for carrots in the Lower Rio Grande Valley. The peak months of these three states do not coincide, but during the months of February, March, and April, the competition is very pronounced between Texas and California resulting in lower prices for Valley carrots (Figures 2 and 3). The highest prices received for South Texas carrots were during December and January when competition from California and Arizona was very light (Figure 3). During February, March, and April the peak volume of total shipments is reached and this is also the period during which the lowest F.O.B. prices exist here in the Valley (Figures 2 and 3).

In addition to competing states, other districts in Texas also compete for the carrot market. The Lower Rio Grande Valley during the five seasons shipped 88.7 per cent of the carrots which were shipped by rail in Texas (Table 1). According to Corns (1956) carrot shipments during

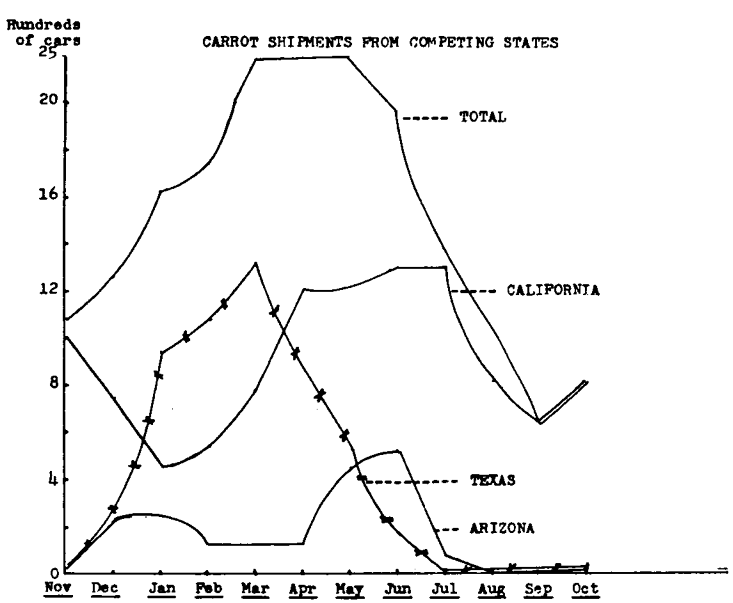

Figure 2 . Comparison of seasons of shipments from competing states. Based on 5-yr. average 1952-56. - Rail shipments. Source of data: Anon(1953-1957).

the five-year period 1951-55 were the highest volume of shipment of the 15 principal vegetables produced in the Lower Rio Grande Valley. Furthermore, during this period there was a steady upward trend in production and volume of shipments.

The carrot-shipping season in the Lower Rio Grande Valley begins early in December and closes in May (Figure 4). The shipments increase very rapidly during December and January, then fluctuate until the third week in March and then decrease until the end of the season in May.

The highest F.O.B. price came during December and then declined toward the end of the season. It is significant that the price per crate fell below the $3.00 mark on the first week in February in each of the five years of the study. On each week thereafter the price continued its downward trend and on only four of the 65 weekly reports after February 1 did the price ever again go above $3.00. These four examples of higher prices came during the last week in April or the first week of May which was near the end of the shipping season.

Since the prices are at their highest level during December, the growers who plant their carrots during the latter part of the summer can expect to receive the highest prices. While yields of these earlier planted carrots may be lower due to poor stands, the high price received will generally more than offset this yield difference. The production of early carrots usually costs more due to higher labor and irrigation costs, but the higher returns usually offset these higher costs and result in very good returns. The production of some early carrots may therefore be a good plan to balance the low returns received for the late spring crop.

Table 1. Comparison of carrot shipments from districts in Texas.*

Month	*Lower Rio Grande Valley*	*Winter Garden*	*Other Texas*	*Total*
		—*No. cars*—**		
December	165	37	36	238
January	845	95	19	959
February	879	160	11	1050
March	1173	80	21	1274
April	790	57	28	875
May	423	62	33	518
Total	4283	397	148	4828
% of Total	88.7	8.2	3.1	100.0

Months shown above are from the beginning to end of season.

*Comparison based on 5-season average, 1952-53 to 1956-57.
**Based on rail shipments.
Source of data: Winfrey, R. E., 1953-57, Marketing Texas Carrots, Lower Rio Grande Valley of Texas (June, 1953, Nov., 1954, Nov., 1955, Nov., 1956, and Nov., 1957). U. S. Dept. Agr. Marketing Service, Fruit and Vegetable Division.

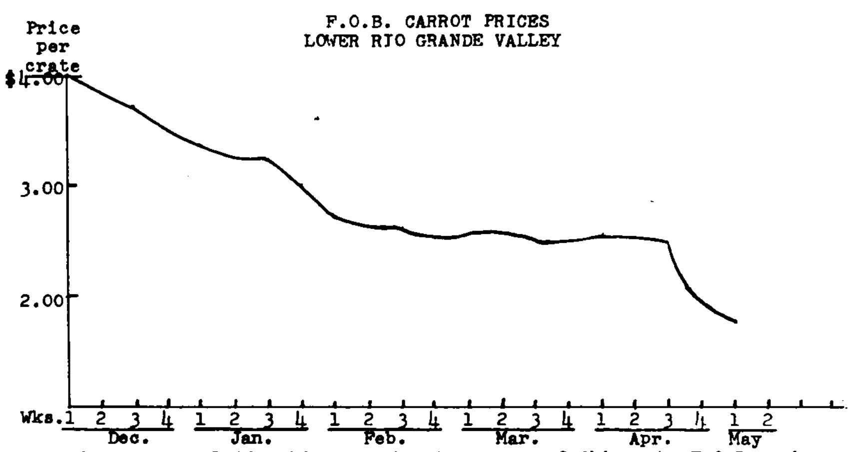

Figure 3. Relationship of Price to Season of Shipment. F.O.B. price for WB crate 48-1 lb. film bags. 5-yr. average 1953-57. Source of data: Winfrey(1953-1957).

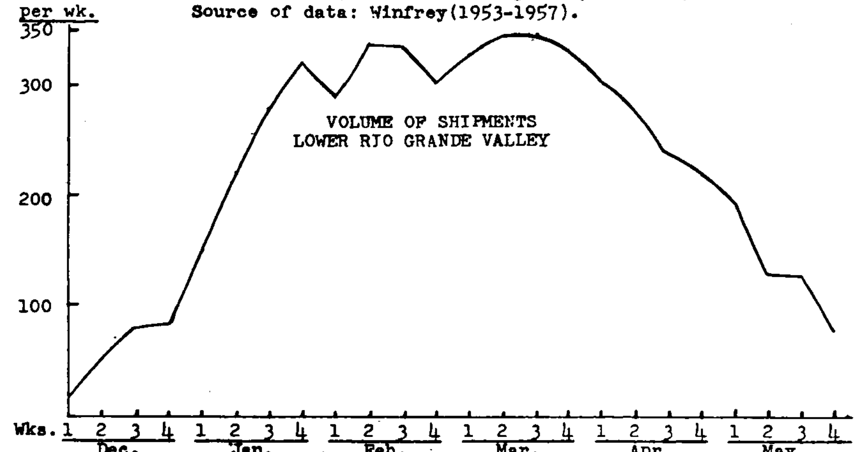

Figure 4. Relationship of volume of shipments to season. Based on the 5-yr. average 1953-57. Shipments include rail and truck. Source of data: Winfrey(1953-1957).

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