JOURNAL

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Aims and Objectives of the Society

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 20 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 barbeque 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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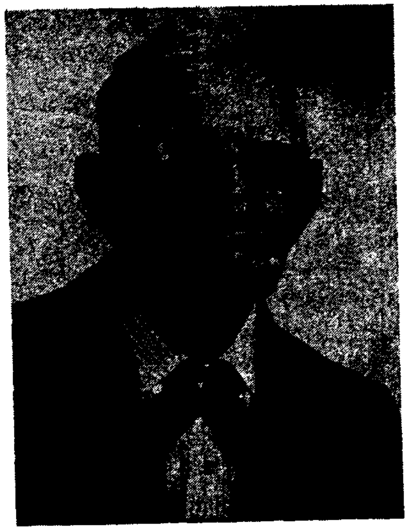

O. F. MARRS,
Recipient of the Arthur T. Potts Award for 1967

By Harry Foehner

Aside from Mr. Marrs himself, w know of no one better qualified to e the story than his daughter, Gwy e-vere Marrs, who took up where ıer father left off. Here is her own ıc-count:

"O. F. Marrs, his wife, and t r two daughters came to the Valle September, 1923 to make their h

"Needing immediate support the family, Mr. Marrs took a job with J. C. Engleman, the realtor, and it was from him that he bought a small tract of land five miles north of Donna. He cleared off the brush and cactus immediately and planted two acres of citrus trees on April 9, 1925. He wanted grapefruit trees, but he had to take 26 navel orange trees in the order. The trees came from the Nuisbickle Warren nursery in California.

"Being a very far-sighted man, Mr. Marrs could visualize the vast areas of brush opening up and the great need for *good* trees. (At that time most of the Valley was still in mesquite brush). So he planted his first seedlings in the latter part of 1925 and budded his first trees in 1926.

"Navel trees are not very prolific nor are they very quick to bear, but in 1927 the trees did have a few fruit on them. Mr. Marrs discovered one limb hanging almost to the ground with heavy *clusters of oranges* – and the perfectly round fruit had no navels!

"He took some of the fruit into the house to show the family, and when I (very small then) showed awed interest, he took me to the orchard and we wondered at the marvel of nature. It was then that the predestined partnership took root that was to put new blood into the orange world.

"There was too much fruit on the limb to afford any bud-wood then, and the same was true in 1928. So in 1929 he snapped the fruit off while in the bloom, affording enough bud-wood for approximately 200 trees. The road was not to be a smooth one, however, for a freeze descended upon the Valley that year, killing all the newly budded stock with the exception of four Marrs trees.

"He planted these four trees out east of our home where some tangerine trees had frozen out. The next year, he used the same procedure saving bud-wood and budded another 200 trees. Another freeze came along and wiped out the nursery with the exception of six Marrs trees.

It also froze the tops out of the four little trees that he had set out. The six tre were planted beside the four.

next year found the ten little trees growing vigorously and by 193 were heavily loaded with fruit when the September hurricane hit Valley. Being heavily loaded with fruit was bad! The limbs were sp own and broken off – and the mother limb on the parent tree also broken off because of the load.

"T last stroke of nature was not only a near destruction of the Marrs ea orange, but it threw the Valley into a depression which it had beer le to avoid up until then.

"E n though the going was lean and depressing, Mr. Marrs nurtured his little trees back into strong heavy producers. There was no sale for trees, but he budded a few Marrs trees each year, bringing the new orange through five generations to prove to himself that it was a true bud strain. Each fruit season, he would take a sample of the Marrs fruit along with his other varieties to the testing station and found it to be earlier than all others, including the parent navel. People would ask him what variety it was, but he kept his own counsel until he had thoroughly proved it out and proved to himself that he had a superior fruit – a boon to the citrus industry.

"He and his wife shipped oranges to friends and relatives all over the United States and Canada to test their shipping qualities and found that they held up in perfect condition due to the perfectly round shape and medium thick skin, as well as well-sealed ends. By cutting many oranges, he found that some had more seeds than did others, but the average count put them in the seedless class. He let them hang – and found that they were still firm on the limb in February and March which is the late orange season, dryness and pithiness never showing up.

"Adding up his years of untiring efforts, his finds were this: His Marrs Early Orange tree bore fruit the first and second years, with a commercial crop the third year. It bore heavily each year with about 90% of the crop growing in heavy clusters of from three to eighteen fruit in a single cluster. The fruit was large and uniform in size on the tree. They were the first to pass the maturity test, making them high in juice and sugar content. They were good packers, shippers, and keepers. He also found that the Marrs tree did not get as large as other varieties, and he reasoned that the tree spent its strength in producing fruit instead of tree. He found that the tree assumed a bush-like picture at the age of three, with its limbs hanging earthward.

"After proving all this to himself (It was then and not until then.), he put a few trees on the market. In 1940 he sold his first 150 trees. Then in 1941 he dug up a little two-year-old tree, laden with fruit, and took it to the Valley Mid-Winter Fair for its formal introduction into the industry. He found that he was forced to put his exhibit behind wire to keep people from cutting off his tree for bud-wood.

"In 1942, another 100 trees were sold. Sales were going slowly because most people were dubious that any tree could have so many cordinal qualities. Realizing that to really put the Marrs orange on the market would require inexhaustable energy, my parents decided that I should take over the *family* tree. A letter was written to me in California where I was engaged in defense work. I accepted the partnership and took over the reins of the business in June, 1943.

"I immediately bought 50,000 seedlings, leased some new, rich land near Monte Alto for the nursery site, and started selling trees on contract basis. Of course, extensive advertising in news items, magazine articles, direct-by-mail brochures, news letters to land owners, and exhibits at the Valley and State fairs each year played a leading role in operations.

"I have carried out other tests for the variety-such as production records. I planted twelve acres of Marrs trees, 100 trees to the acre, in December, 1945. On October 1, 1948 (the trees were two years and nine months old), I harvested 48 tons. In 1949, a freeze was experienced when the trees were in bloom, but on September 13, 1950, I harvested 64 tons."

Now for something about Marrs himself. He was born 85 years ago, Dec. 28, 1881 and at age year and a half moved to Meade County, Kansas in a covered wagon. There he drilled the first artesian well in Artesian Valley, the beginning of most of the agriculture in Kansas now under well irrigation.

He studied mechanical engineering at Kansas State University and married Maude Ella Pinnick in Fowler, Kans. where he operated the city power plant.

He moved to Los Angeles and began working for the Ford division there. It was his job to work the bugs out of the new "Tin Lizzies," reporting his findings directly to Henry Ford who would order necessary tooling changes at the factory.

Later he returned to Kansas in a Model T Ford over mere wagon trails. About that time, the inventor of the combine ferreted out the young and clever machinist, Otto Marrs, who spent months at Hutchinson making and fitting together the parts as the plans came to him from the drawing board.

In 1923 he brought his family to Texas, starting his nursery in 1925. When the Ferguson Ford hit the market, Marrs was immediately interested and started hooking up unique pieces of machinery to the tractor to adapt it to this area.

He was the first to make a three point hookup border disc, and many other arrangements. Eighteen years ago he rigged up a spring-shanked Ford cultivator for his orchard and threw away his disks. Many orchard owners and caretakers have found the cultivator to be a great moisture saver.

Without the help of his wife, Maude Ella, the "family tree" might still be a "bush" for it was she who packed out Marrs oranges by the bushels and expressed them to friends all over the United States to determine their shipping quality, keeping quality and to get consumer reaction to their quality.

Present status of the Marrs orange is a tribute not only to the discoverer and his daughter but also to his wife.

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ADDRESS OF WELCOME

21st Annual Horticultural Society Institute

This date marks the 21st consecutive annual Citrus Institute Meeting and it is a real pleasure, in behalf of the Rio Grande Valley Horticultural Society, to extend to each and everyone a warm welcome. This Institute is now recognized as being one of the outstanding meetings each year in our Valley; and without your presence, your interest and cooperation it could not have achieved this useful Goal.

We wish particularly to recognize and welcome the "out of Valley" and "out of State" visitors here today. An increasing number of out of Valley property owners and winter visitors attend this Institute each year, and for which we are pleased. At this time ALL OUT OF VALLEY visitors please stand and be recognized with a "round of applause." Thank you. This day gives us a chance to renew old friendships, make new ones and to discuss our ideas and problems together. The rich value of the Institute is, of course, in the program for the day where progress and development if research and its applied application as pertaining to our Valley need is given full attention. There is, and will continue to be, much work in both fields to challenge us in the progressive and profitable field of our Valley agricultural economy.

To those here today who are not members of the Horticultural Society – we urge you to join – the annual dues are only $4.00 and which covers the monthly newsletter to all members, and a copy of the Horticultural Society Journal which alone is worth more than $4.00. Those who wish to join, or renew their membership, please see the young ladies at the desk in this room who will fill out cards for you. The Society meets the last Thursday night of each month in these buildings, and we invite all interested persons to attend these meetings.

It would be amiss not to express at this time our sincere thanks and appreciation to the speakers on the program today; to the M.C. Program announcers; the lady registrars; to the various committee chairmen and members who planned and did the tremendous work in making this meeting possible and a success; last but not least to the Texas A. & I. Citrus Center for providing the use of these building facilities for this Institute and meeting room for the Society throughout the year. Stand up Dr. Richard Hensz, director of the Center, for recognition. Applause. Again a warm welcome to each of you and we trust this day may be enjoyable as well as fruitful to you.

NOEL E. RYALL, *President*

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B. C. Stephenson
Box 455, Harlingen
Orval Stites
Box 182, Donna
Benton Storey
Hort. Dept.
Texas A&M University
College Station
John C. Summers
1517 Whitewing, McAllen
A. R. Swanson
Rt. 1, Box 26, Alamo
Harry Swofford
Box 3688, McAllen
Sam D. Tayloe
Rt. 1, Rio Farms, Inc., Edcouch
Elmslie T. Thomas
Box 204, Alamo
Don E. Thompson
Rt. 2, Box 20-A, Weslaco

E. E. Thompson
Rt. 1, Box 44B, Alamo
Franklin M. Turrell
3574 Bandina Ave.
Riverside, California
R. D. Van Nordstrand
712 Upas, McAllen
J. H. Vertrees
Box 845, Donna
George W. Vest
1301 S. Texas Blvd., Weslaco
M. T. Waddell
Box 4255, Baytown
Jerry Walker
Box 733, Pharr
Ed Wallace
1217 Quince, McAllen
George P. Wene
Cotton Research Center
4201 East Broadway
Phoenix, Arizona

Earl Wetzel
Rt. 1, Box 192-A, La Feria
Glenn White
P. O. Box 505, Donna
Craig L. Wiegand
Box 267, Weslaco
Leon M. Wilder
Box 305, Alamo
N. R. Willis
Box 2278, Brownsville
Howard S. Wright
Rt. 1, Box 447, Weslaco
John L. Wright
Rt. 3, Box 52, Los Fresnos
Otha A. Wyrick
822 E. Taylor, Harlingen
Roger Young
607 Kansas, Weslaco
James E. Zeigler
714 Camellia, McAllen

CITRUS

Citrus Outlook for the Rio Grande Valley[1]

JAY D. BOGUE[2]

It is an honor to be on the program of the Rio Grande Valley Horticultural Society Annual Institute and a pleasure to speculate along with you all as to the citrus outlook a few years from now. In discussing the citrus outlook, one point should be kept in mind – if there is anything certain about citrus, it is the very uncertainty of it.

Citrus is grown over a wide range of latitude, about 35° north and south of the equator. Generally, anywhere within this belt at a relatively low altitude, citrus can be grown if water and soil conditions are suitable. However, within the tropics where freezes never occur, the fruit is generally of inferior quality. This limits the area of successful commercial production to the cooler areas of the semi-tropical zone.

This fact is responsible for one of our first uncertainties, and believed by many the most important to the citrus industry – the problem of frost or freeze damage to the fruit and trees. This condition is not the exclusive problem of any one producing area, and the commercial citrus producing areas of the United States are no exception. Here in Texas our citrus growers and others in the industry have vivid memories of what effect cold weather can have on the industry. The same situation also exists in Florida. In California, the growers go to great expense and effort to guard against this hazard. They have learned over a period of years that frost protection is a necessity, as are other orchard operations, such as irrigation, weed, and pest control.

We have seen the Texas and Florida citrus production drastically reduced as a result of cold weather. We have seen both of these areas make remarkable recoveries from the adverse weather of 1962. Based on the USDA forecast for this crop year, the Florida production has more than doubled and the Texas production has increased some 14 fold.

The question follows, will future production continue to increase at this remarkable rate, and if so, what effect will it have upon profit to the grower?

Texas Citrus Mutual recently released citrus tree data for the Rio Grande Valley. This data (Table 1) provides the number of trees and total acres of early oranges, Valencias and grapefruit, by three age groups. Using this data and the yield data (Table 2) published by

[1] Presented at the Twenty-first Annual Horticultural Institute, Rio Grande Valley Horticultural Society, Weslaco, Texas, January 24, 1967.
[2] Manager, Texas Citrus Mutual, Weslaco, Texas.

Texas A&M in their Guide for Citrus Production in the Lower Rio Grande Valley, it is relatively simple to arrive at a future crop estimate.

Table 1. Citrus Tree Data from Texas Citrus Mutual.

Age of Trees	Early Oranges No. Acres	Early Oranges No. Trees	Valencia Oranges No. Acres	Valencia Oranges No. Trees	Grapefruit No. Acres	Grapefruit No. Trees
0 – 4	8,977	936,430	3,520	371,858	6,943	757,082
4 to 8	5,442	477,456	4,221	337,513	7,765	642,453
8 or over	8,471	629,170	8,677	620,519	20,096	1,540,222
Total	22,890	2,043,056	16,418	1,329,890	34,804,	2,939,757

Table 2. Yield Per Acre for Texas Citrus. (116 Trees Per Acre)

Age in Years	*Grapefruit (tons/acre)*	*Early & Mid-Season Oranges (tons/acre)*	*Late Season Oranges (tons/acre)*
3	1	0.7	0
4	2.5	1.2	0.4
5	6.5	3.0	1.3
6	10.0	5.5	3.0
7	16.0	8.0	5.0
8	18.0	10.0	7.0
9	19.0	12.0	9.0
10	20.0	14.0	10.0
11	21.0	15.0	11.0
12+	22.0	16.0	12.0

Since the yield data (Table 2) was based on 116 trees per acre, and the tree census data averaged somewhat under this figure, it is necessary to divide the number of trees in each category by 116 to determine a hypothetical acreage by variety and age group. The next step involves arriving at an updated average age of the trees in each age grouping, taking into consideration the time interval since the census was initiated.

The average tree age is then advanced to 1970 and using Texas A&M average yield data, (Table 2), the computation indicated a projected crop of 11 million boxes of grapefruit, 4.2 million boxes of early oranges, and 2.3 million boxes of Valencias – 17.5 million boxes total crop.

Florida Citrus Mutual recently published[3] an orange crop estimate of 190 million boxes for 1970, based on an estimated 800,000 acres in production. Since data was not provided on expected grapefruit production, it was necessary to make a projection based on present bearing acreage, advancing the age of non-bearing acreage[4], and yield per acre. This projection indicated that by 1970 Florida would have in production 98,000 acres of grapefruit and, based on an average yield of 450 boxes per acre[5], the projected grapefruit production by 1970 would be some 44 million boxes.

These projections provide the basis for an answer to the first question and indicates a substantial increase in orange production by approximately 33% by 1970, and approximately a 22% increase in grapefruit production.

What effect will this increased production have on profit to the grower? The answer to this question is very difficult, as there are so many variables. To name a few – cost of production, yield per acre, per capita consumption, and certainly not least, the general economic condition of our country.

From the standpoint of the grower, two of the above variables that are extremely important are under the control of the grower. These are the cost of production, and the yield per acre. The citrus industry has been faced with an increasing production cost for many years. Tractors, fuel, labor, chemicals – have been going up and this trend is expected to continue.

Our research people have been busy and can help us in many ways to reduce our production costs. Two examples of the results of their work are land leveling and chemical weed control. As we drive through the Valley today, we see many groves that have been leveled with permanent borders. The man hour cost to irrigate leveled groves is only a fraction of the cost of irrigating non-leveled groves that still exist throughout the Valley. Many growers are going to chemical weed control and have found that they can save money after the first year or so. Each and every grower, IF he expects to show a profit, must find ways to reduce his cost of production to the absolute minimum necessary to produce GOOD fruit.

A few years ago it was fairly standard to plant trees at some 50 to 60 trees per acre. In recent years the trend has been to plant more trees per acre. It is generally accepted that plantings of 116 trees per acre will initially produce twice as much fruit per acre as the old 56 tree per acre plantings. However, the production cost per acre is only slightly more for the 116 tree plantings.

The on-tree prices received by the grower for citrus fruit has been declining on a year to year basis for the past few years. In mid-January

3 Florida Citrus Mutual Triangle, January 13, 1967.

4 1965 bearing and non-bearing acreage from Federal-State Market News Summary, 1965-66 season. 1970 acreage computed on the basis of non-bearing acreage existing in 1965.

5 1965 grapefruit crop divided by producing acreage would indicate an average of 434 boxes per acre. 1966 yield, 460 boxes per acre, based on bearing acreage and USDA 1966 crop estimates.

the growers were receiving between $15 and $22.50 per ton on the trees for early and mid-season oranges. At $20 a ton and 5 tons per acre, a grower will gross $100 per acre, well under the cost of production. However, at 20 tons per acre, the operation changes from a loss to a profit. The grapefruit grower has fared much better in the past couple of years in the price received per ton for his fruit; and again in mid-January, the on-tree price for grapefruit was generally $25 to $30 per ton. At this price, with a yield of 20 to 30 tons per acre, the grower can realize a good profit on his orchard. Most authorities are convinced that groves that do not have a potential for a minimum production of 20 TPA should be considered marginal.

During the past 35 years the per capita consumption of citrus, fresh weight equivalent, has varied from a low of 37.5 pounds per person to a high of 95.3 pounds per person. The conclusion has been drawn by some that the per capita consumption for citrus production is declining. However, a close examination of the per capita consumption and the United States citrus production tends to bear out a very elementary point . . . *per capita consumption varies with production.* During periods of low production the per capita consumption drops and during periods of high production the per capita consumption increases. For example, in 1962 the U. S. per capita consumption stood at 82.9. The following year it dropped to 62.6 pounds per person, coinciding with the drastic drop in production as a result of the 1962 freeze. In 1957 the per capita consumption was 88.7 pounds per person and in 1958 it dropped to 76.5 pounds per person; following again the reduced production resulting from a freeze in Florida, which lowered production some 20 million boxes.

During the period of reduced production, and high prices after the 1962 freeze, several new drink products appeared on the market and filled the void then existing. With increasing production and lower prices, the consumers have been switching back to citrus, which resulted in an increase in per capita consumption of 10 pounds in 1965 over 1964. With the food bargain in citrus existing today, this rate of increased consumption of citrus fruit will continue. The cost to regain our markets has been great. This can be prevented, or at least reduced, in the future through continued cold protection and cold hardiness research as well as through acceptance and utilization of the most efficient and effective cold protection devices. California citrus growers learned this fact long ago. We Texas citrus growers cannot afford to take the risk of again losing our markets and groves.

At the 95.3 pounds per person per capita consumption of 1946 and today's population, which is approaching 200 million, there is indicated a consumption in excess of 19 billion pounds of citrus. Our current crop, which is the highest ever experienced in this country, amounts to 19.9 billions of pounds of grapefruit and oranges, and some 400 million pounds of tangerines; or a total of 20.4 billion pounds of citrus, not including lemons (USDA estimate Jan. 1, 1967). Keep in mind that this 20 billion pounds is total crop, and will be reduced considerably by

culls, spoilage, etc. With the standard of living in this country, there certainly seems to be a need for a crop of this size.

The Texas citrus industry has one advantage, other than the superior quality of the Ruby Red grapefruit, that is extremely important – this is the central location and reduced distance to markets. An equal distance line drawn on the map of the United States between the citrus producing area of Florida and the producing area of Texas would fall, roughly, along the Mississippi River. West of this area, Texas has an advantage over Florida due to closer markets. Since the fruit of these two areas compete on the basis of delivered prices, this saving in freight is available to the Texas producers. That portion of the United States which lies west of Minnesota, Iowa, Missouri, Arkansas and Louisiana contains 26% of the total United States population. Furthermore, this is the fast growing section of our country, with an increase in population of 45% from 1950 to 1960. The consumer potential of this area is sufficient to utilize much of the expected increasing citrus crop.

Based on our production estimates for 1970, the Texas orange crop will amount to 3.3% of the total Texas and Florida production and the grapefruit crop will represent from 20% of the total. This would indicate the Texas fruit will be sold much closer to the producing area than Florida's crop, and that the Texas grower will receive a better price for his crop due to the lower transportation costs.

Undoubtedly, the low prices being received by the Florida grower for his fruit this year will slow down new plantings in Florida. However, the population explosion that is occurring within our country and the rapid shifting of our population to the west should and will encourage the planting of additional acreage in Texas. While there are year to year variations in the profitability of oranges or grapefruit, the long range outlook is certainly in favor of the Texas citrus industry.

Outlook for Citrus Processing in the Rio Grande Valley[1]

FRANCIS P. GRIFFITHS
Food Crops Utilization Research Laboratory, Weslaco, Texas[2]

There are two things wrong with any prediction about the outlook for citrus processing for the Rio Grande Valley. In the first place, no one can define all factors influencing processing and therefore any forecast is sure to be inaccurate, and secondly, we cannot control the weather, and, in past history, weather in the form of a freeze, has been the biggest single factor influencing citrus production and therefore processing.

Mr. Bogue has presented a very able analysis of the prospects for increasing citrus production in South Texas. We agree quite closely on estimated total production for 1970. In this discussion, three charts are used to emphasize several points.

The first chart demonstrates an unpleasant fact – that Texas citrus production is small potatoes, as a part of the total. The dominating area is Florida, with California second in influence. Texas produces only 4.3% of the orange crop. Texas does much better with grapefruit, and produces 15% of the total crop.

The topic of this paper is not production but processing. Chart 2 shows what Florida and Texas process. The striking thing about this chart is the high proportion of fruit which Florida processes. Florida no longer grows oranges primarily to sell fresh, but grows them primarily to sell as canned orange juice or frozen orange concentrate. *Over 81% of Florida's oranges are processed.* The proportion of grapefruit which are processed is smaller – Florida processing 50.3% of its production. A constantly increasing quantity is being converted to juice, orange-grapefruit blends, and into salad packs.

Texas processes fewer oranges than grapefruit – only 13.2% of our orange production is canned, where as 23.4% of our grapefruit crop is processed.

The third chart (8) portrays the history of citrus production in the Valley. This chart ended at 4.6 million boxes for 1964-65. Production for 1965-66 was 5.1 million boxes. We have put in this year's estimate of

[1] Speech presented at the 21st Rio Grande Valley Horticultural Institute, January 24, 1967.
[2] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

Chart 1

Citrus Production, 1966-67 Estimate
in millions of Boxes

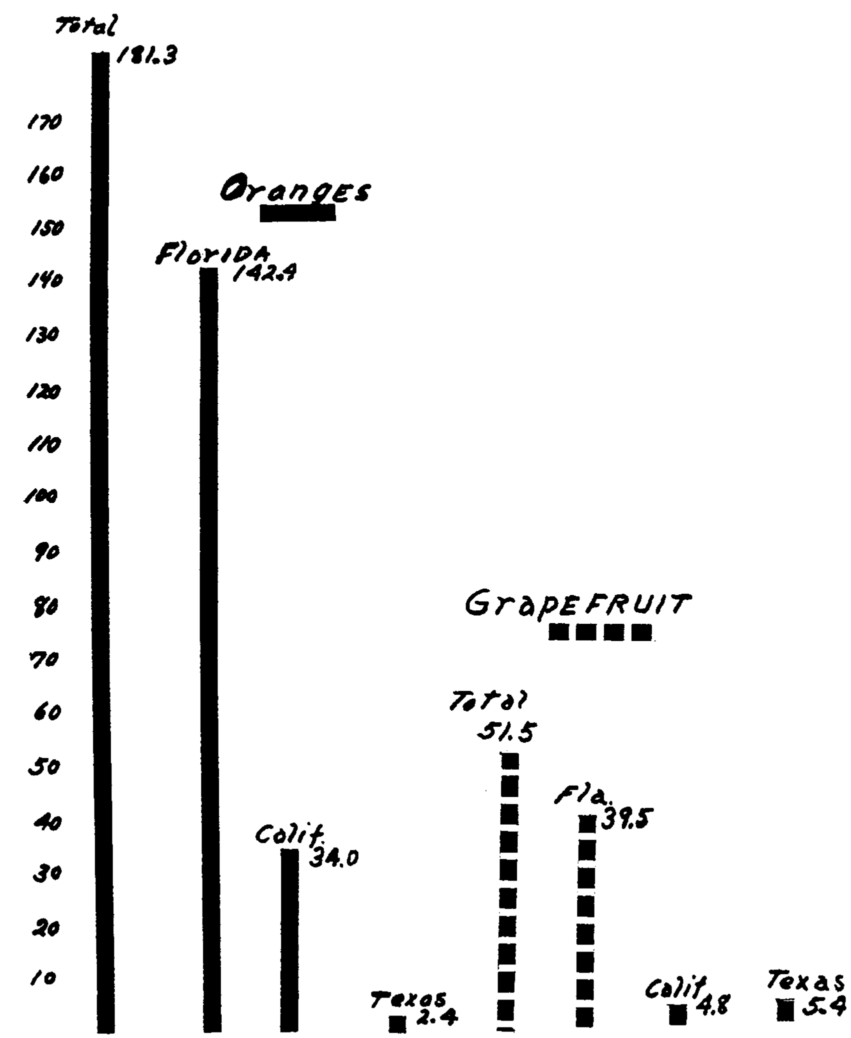


Chart 2

Proportion, %, of Crop Processed.

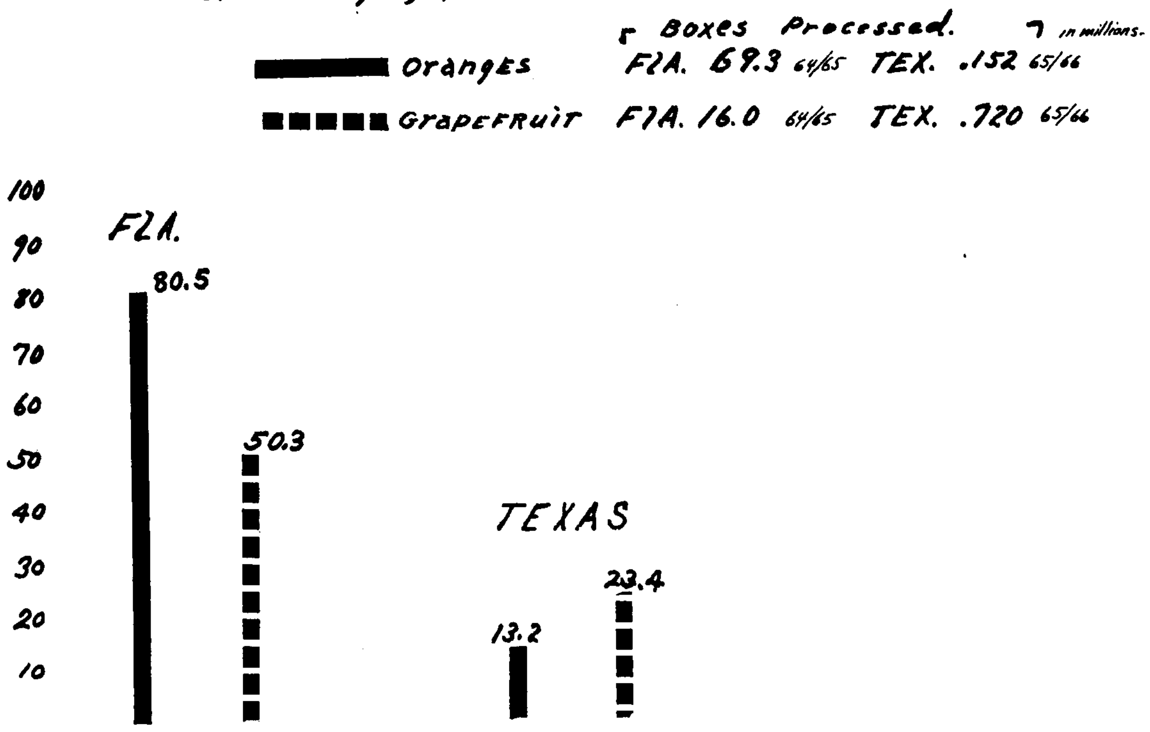
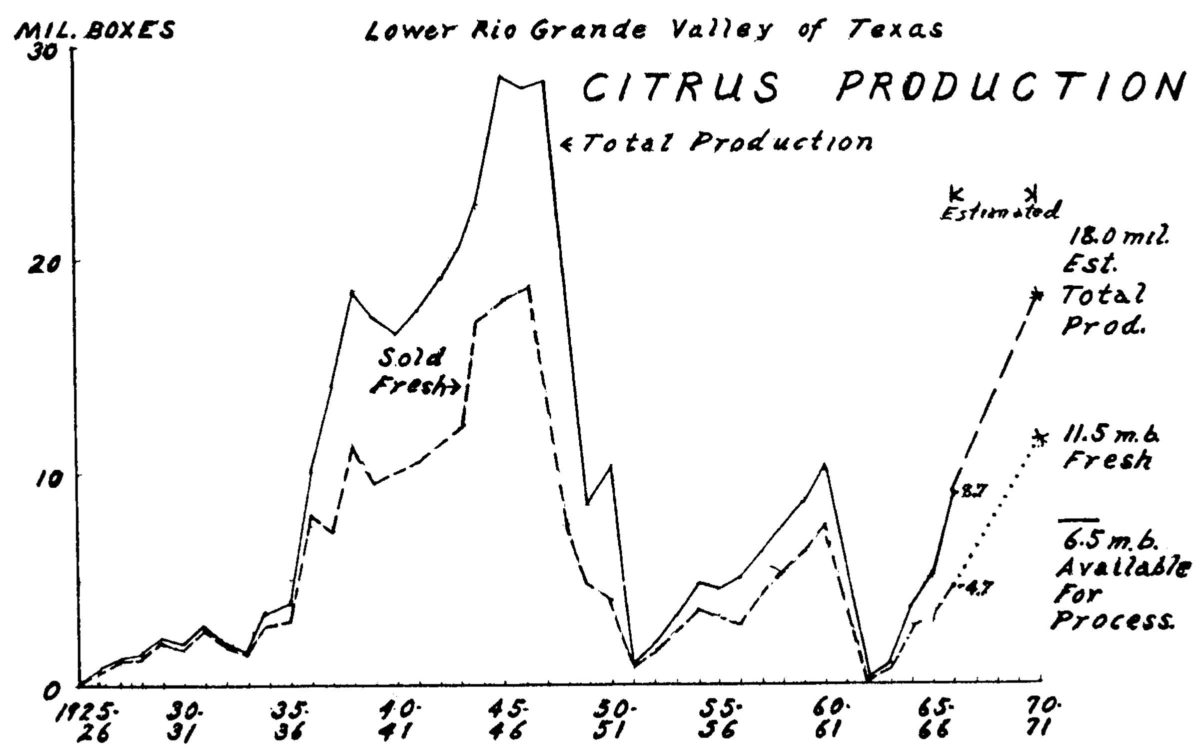


CHART 3



a total of 8.7 million boxes; the prediction is that this will reach 18.0 million boxes by 1970 (if it doesn't freeze). Of this 18 million boxes we expect approximately 6.5 to 7.5 million boxes to be available for processing – an increase of about 3-fold over the amount that will be processed this year, now estimated at 2.3 million boxes.

Even if only 60% of fruit available is processed it will mean a doubling of processing capacity. *In 1947-48 there were about 36 citrus processors here.* Today we know of *only four* – Texsun in Weslaco, Knapp-Sherrill in Donna, Mission-Harlingen Canning Company in Harlingen and Magic Valley Foods in Monte Alto. To expect a 3-fold expansion to occur the Valley will have to gear itself to consider fruit processing as a basic industry – not as a salvage operation or a temporary way of using fruit when it cannot be fresh-marketed.

It is necessary to emphasize that while continuing to strive for the maximum amount or share of the fresh market, the Valley should seek to provide a stable basis, a sound foundation, for an enlarged processing industry. Let's not kid ourselves – the only alternative to this is to figure on plowing under a large proportion of our increasing production.

Florida has committed its citrus industry to industrial use. As its production increases, if Mr. Bogue's calculations are correct, then more of its fruit, and particularly oranges, will be processed. And the new families, the younger generation, are accustomed to getting their juice out of a can as well as their instant coffee out of a jar. The processed product supply from Florida will determine, to a great degree, the market demand and price.

This means that the Valley will have to keep up with other areas in efficiency of operation, production, in mechanical harvesting, handling, processing and transportation.

To retain its share of the fresh fruit market, it will have to pay the utmost attention to quality; it cannot afford to market or allow others to market unripe, low-quality fruit. The Valley has the best red grapefruit there is and it deserves to be appreciated, and to reach a wide market.

As regards canned orange and grapefruit juices, we will have to advertise, advertise and advertise; and we will have to emphasize quality, quality and more quality.

The Weslaco Fruit and Vegetable Products Laboratory (4, 2, 5) showed that a good canned juice can be made from red grapefruit, the more color it contained the better, and by 1960-61 some canners were getting more for pink grapefruit juice than for white. But to get the best quality juice, either white or red, the fruit must be separated, red to one process line, white to another, for when mixed fruit is canned, an off color juice results.

Ten years ago this laboratory demonstrated that red grapefruit-

pineapple-citric acid-sugar-water blends made an excellent drink (3, 6). This last season one of the largest California-Hawaii canning companies, Dole, sold millions of cases of pineapple-pink grapefruit juice drink, a mixture of, to quote from their label, "water, concentrated pineapple and pink grapefruit juices, sugar, corn syrup, citric acid, sodium citrate, natural flavoring, gum arabic, ascorbic acid, artificial color. Patent Pending."

Several years ago, the Fruit and Vegetable Products Laboratory developed formulations for grapefruit-berry-lemon-sugar punch concentrate; one of the best mixes was a grapefruit-Valley strawberry-Meyer or Eureka lemon-sugar preparation. Everybody thought it was good, especially the kids that won't touch grapefruit juice – but nobody has done anything with it (7).

At a meeting in California recently, University of Arizona researchers reported, and again we quote, "Initial acceptance is high for grapefruit juice blended with 10-15 percent strawberry, red raspberry, boysenberry or olalieberry juice, when grapefruit juice acidity is 1.5 percent or less and sugar is added to give 14-16° Brix." Now who is going to get on the market with a product? Florida? California? Arizona? or Texas? It's a free world.

It is the function of the Food Crops Utilization Research Laboratory – our new name – to keep abreast of technological advances and to try to assist industry by the development of improved processes and new products.

This laboratory showed that it was possible to remove excess bitterness from grapefruit juice or slices by use of an enzyme (2). Florida State Citrus Experiment Station at Lake Alfred now has a research contract to develop practical pilot plant and in-plant applications of this procedure. The Japanese are using an enzyme to debitter some of their canned mandarin-tangerine sections. We could debitter red grapefruit pulp and use the pulp to give a redder red to our grapefruit products. Maybe we should use the enzyme to debitter the grapefruit sections used in a chilled pineapple-grapefruit salad mix.

Other possible citrus products should be considered. Before 1962 the Valley had four concentrate plants in operation. Now only two remain, and only one of these is operating this year. As the Valley grows more citrus, it is imperative that it seek a share of the citrus concentrate market. It is fortunate that Ruby Red grapefruit will make an attractive and very well-flavored concentrate – not as red as we would like, but certainly one having a distinctive color which can be capitalized upon by proper advertising. Research workers are now working on a method of concentrating liquids, called reverse osmosis, which may be much less expensive, both in equipment and cost of operation than the present low temperature high vacuum evaporators used for preparing concentrates. We are watching this development with much interest.

Freeze-drying is a possibility for both grapefruit and orange juice, but this is an expensive process and USDA researchers have developed a less expensive process called foam mat drying. In this process, hot dry air is blown through a foamed layer of citrus concentrate which is carried on a porous moving belt until the foam is dry and can be scraped off as a powder. Citrus oil is added back and a natural flavored juice is produced when the orange or grapefruit crystals are stirred into the proper amount of water.

With the increase in efficiency of small amounts of preservatives, such as the benzoates and sorbic acid, an increasing amount of both orange and grapefruit sections are being processed into chilled fresh salad mixes. Most of this is being made in Florida. So far as I know, no one in the Valley is preparing these products. However, we can assure you that the Valley should explore their possibilities. We are excited about what we consider to be superior color, firmness and sectioning quality of a little-known Valley red grapefruit, the Hudson. You can see here and after the talk how much this fruit contains larger and more highly colored sections that those of the Ruby Red grapefruit. Unfortunately, the fruit sas seeds and because of this its possibilities have been neglected.

Certainly the Valley should, *must* is a better word, make use of every possible way of marketing its citrus. An Arizona firm uses a grapefruit base for Squirt, and we have another excellent grapefruit flavored drink in Wink.

We hope to initiate research on possible uses for the whole fruit, excepting the seeds, as a comminuted flavoring base for bakery items, carbonated drinks, candy and blends of jam and jelly. It will take technical know-how and imagination, but we are eager to work out the possibilities. Perhaps this laboratory can hit a jackpot.

In conclusion, we know the Valley will increase in citrus production and with this increase there must come a substantial increase in the amount of citrus processing. It is hoped that many new products can be developed which will increase the diversification and utilization of processed citrus. It is up to all of us to unite in our efforts to build both a fresh and processed profitable citrus industry for the Valley.

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Trends of Mite Populations in Lower Rio Grande Valley Citrus Groves in 1962-63 and 1966-67[1]

D. K. REED[2], S. J. INGLE[3], W. G. HART[2], and J. W. BALOCK[2,4]
Entomology Research Division, Agr. Res. Serv.,
USDA, Weslaco, Texas 78596

Abstract: Surveys of mites associated with citrus in the Rio Grande Valley were made in conjunction with surveys of brown soft scale, *Coccus hesperidum* L. June 1962 to May 1963 and June 1966 to May 1967. The results indicated that populations of the Texas citrus mite, *Eutetranychus banksi* (McGregor), and the citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), were much greater on trees just recovering from the 1961 freeze than on the same trees 4 years later. Whether the difference in populations was caused by tree condition or other environmental factors is unknown. Presence of other mites in the surveys is discussed.

In June 1962 immediately after the 1961-62 freeze, monthly surveys of mite populations were initiated in conjunction with surveys for brown soft scale, *Coccus hesperidum* L. (1) in citrus groves. After a year of such surveys, mite counts were discontinued as a regular supplement to the scale survey, and only general observations of mite populations were made. In 1966, we decided that a comparison of general trends of mite populations at that time with the 1962 immediate post-freeze populations would be of interest. Accordingly, mite surveys were made as a part of the regular survey for 1 year beginning June 1966 corresponding with the monthly 1962-63 counts.

As noted, surveys in 1962-63 were made on severely freeze-damaged citrus trees that were then recovering with sustained rapid growth and addition of new foliage. The 1966-67 surveys were made on mature, bearing trees that were considered fully recovered from the freeze with normal flushes of new growth during the year.

SURVEY METHODS

Counts were made in citrus groves previously selected for survey of brown soft scale. These groves extended from one end of the Valley to the other with Roma the western limit and Brownsville the eastern limit. The general geographical grouping of the groves was east, mid, and west Valley with Harlingen the line between east and mid-Valley and Alamo the line between mid and west Valley. Twenty-six groves were included in the 1962-63 survey, but only 20 were surveyed ir 1966-67.

1 Mention of proprietary products herein does not imply endorsement of these pro ducts by the USDA.
2 Research Entomologist.
3 Agricultural Research Technician.
4 USDA, ARS, ENT, Plant Industry Station, Beltsville, Maryland 20705.

Eight single leaf samples growing at shoulder height were picked randomly from each of 30 tagged trees in each grove. These leaf samples were brought into the laboratory and brushed in a Henderson® mite-brushing machine (2); the mites fell onto a 5-in. glass plate coated with detergent. One-fourth plate counts were made under stereoscopic microscopes, and total mite populations (eggs and motile forms) were tabulated. Counts included Texas citrus mite, *Eutetranychus banksi* (McGregor), citrus rust mite, *Phyllocotruta oleivora* (Ashmead), *Brevipalpus* sp., *Tydeus* sp., and phytoseiids, a predaceous group of mites.

RESULTS

Population trends of the Texas citrus mite and the citrus rust mite in the 3 geographical areas and in the entire Valley in 1962-63 and 1966-67 are presented in Figures 1 through 8.

Texas citrus mite. Highest populations of Texas citrus mites in both surveys were recorded in west Valley citrus groves (Fig. 1). In 1962-63, very large numbers were present from October to January with a marked drop in populations by February; in 1966-67, the highest populations were again recorded in the winter months but the seasonal decline occurred one month earlier. Mid-Valley groves (Fig. 2) were not as heavily infested, but in 1963, the highest numbers were present in January and the decline occurred in February; in 1966-67, highest numbers of mites were recorded in April, but a decline occurred between December and January. In the east Valley (Fig. 3) where Texas citrus mite is not considered a problem except in isolated instances, both surveys showed only low numbers of mites, and groves were practically free of infestations during the fall and winter of 1966-67. Mean averages for the entire Valley (Fig. 4) showed that the numbers of the Texas citrus mite were much greater in 1962-63 than in 1966-67 and that the seasonal decline occurred in February of 1963 and in January of 1967. Egg counts are not included in the graphs, but we could usually detect a correlation between increased numbers of eggs one month and increased mite populations the following month.

Citrus rust mite. Population peaks of rust mites occurred in November, December, and January of 1962-63 except in the west Valley (Fig. 5) where the largest numbers appeared in July; however, this high number is deceptive because virtually all the mites were from one grove that had a total of 257 mites per leaf, and the other groves in the survey area were relatively clean. Except for this one grove, the west Valley had lower numbers of rust mites in both surveys, as expected, since temperature is usually higher and humidity lower than in mid and east Valley groves where citrus rust mite is generally more of an economic problem. Figures 6 and 7 show the great difference in populations in 1962-63 and 1966-67 in the mid and east Valley. Peaks in 1966-67, such as they were, occurred in August in the east Valley, and in December and April in the mid Valley. Rust mites were much more numerous throughout the Valley in 1962-63 than in 1966-67 (Fig. 8).

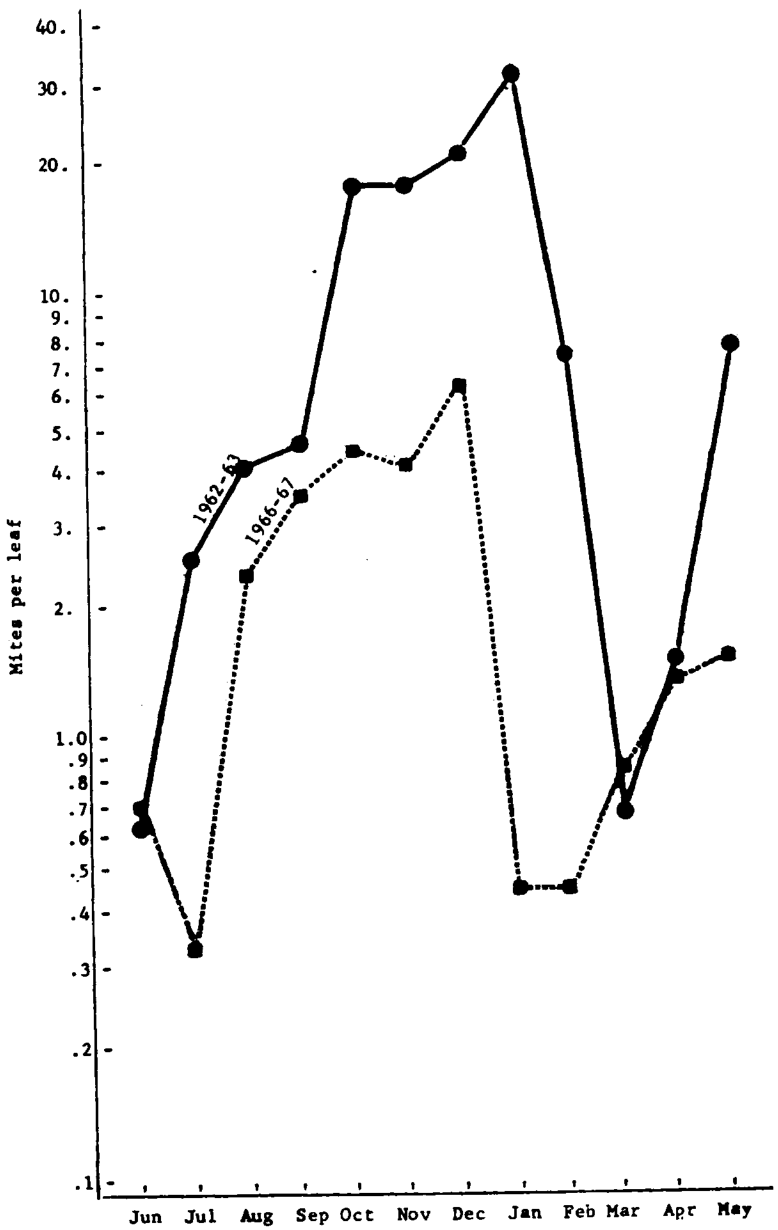

Figure 1. West valley: mean populations of the Texas citrus mite.

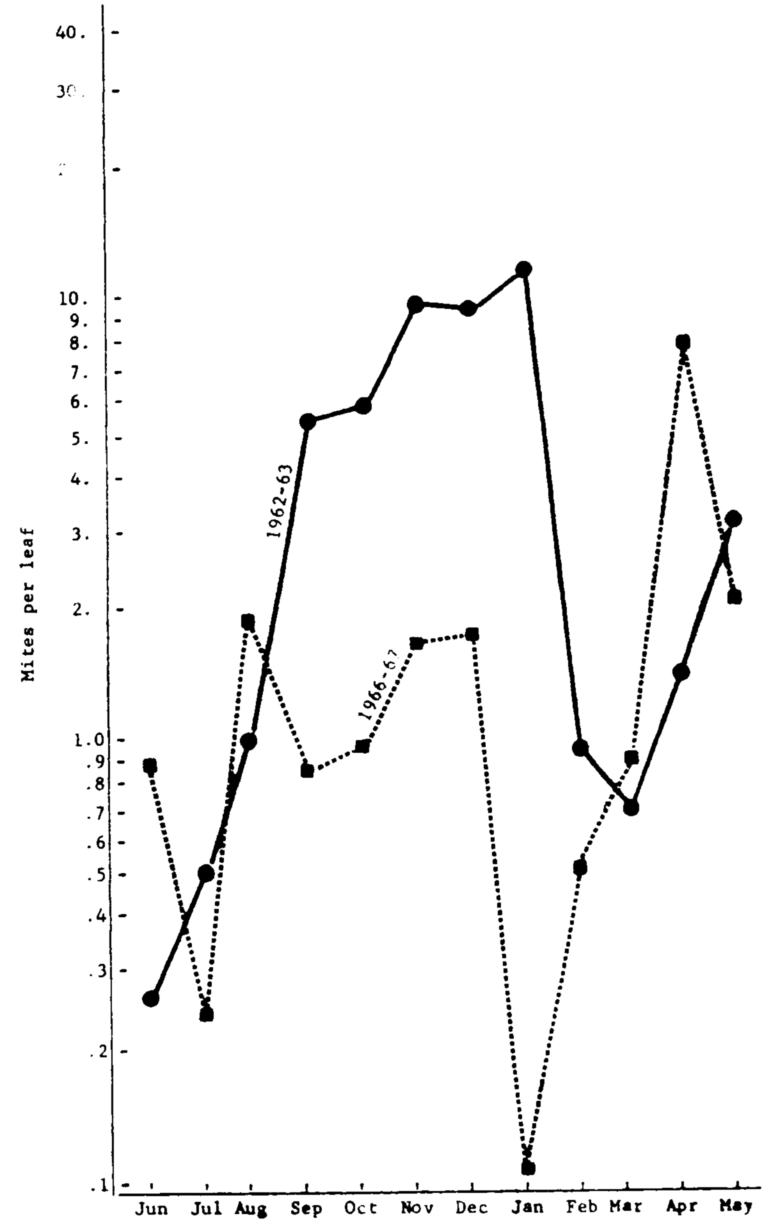

Figure 2. Mid valley: mean populations of the Texas citrus mite.

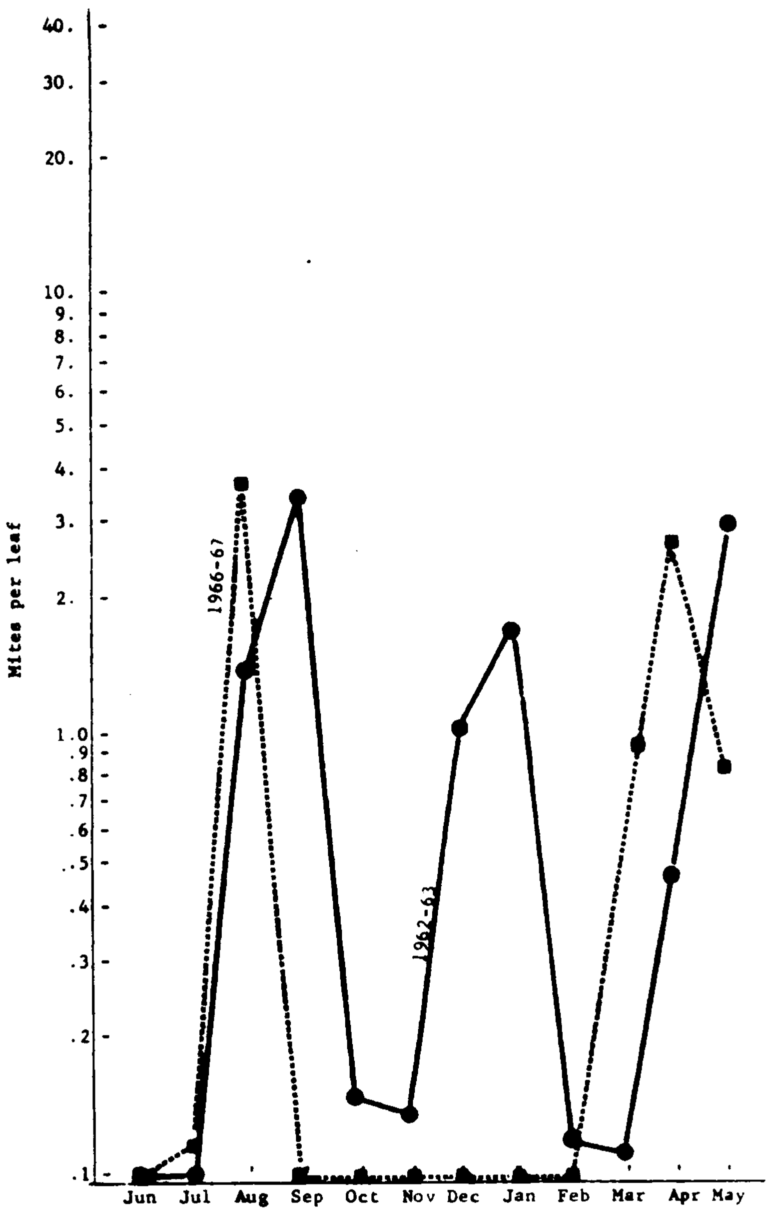

Figure 3. East valley: mean populations of the Texas citrus mite.

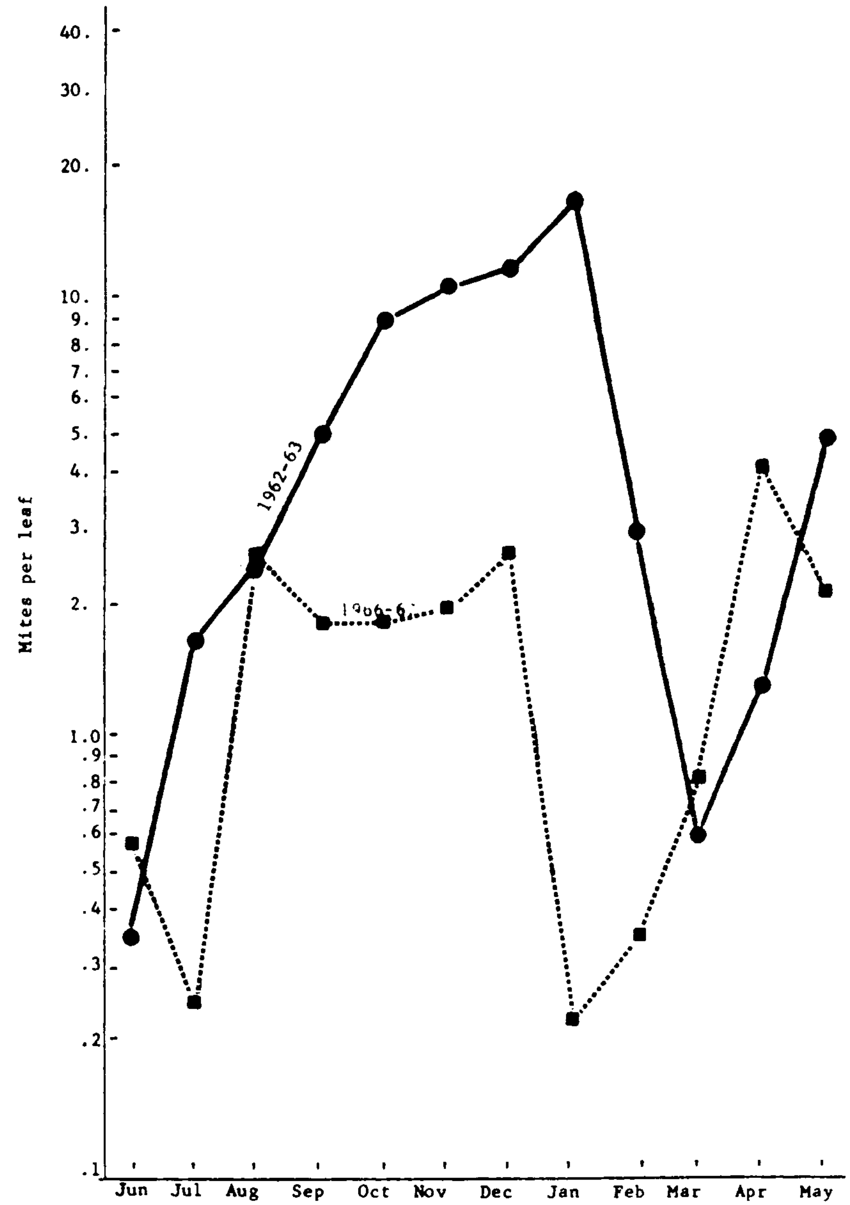

Figure 4. Entire valley: mean populations of the Texas citrus mite.

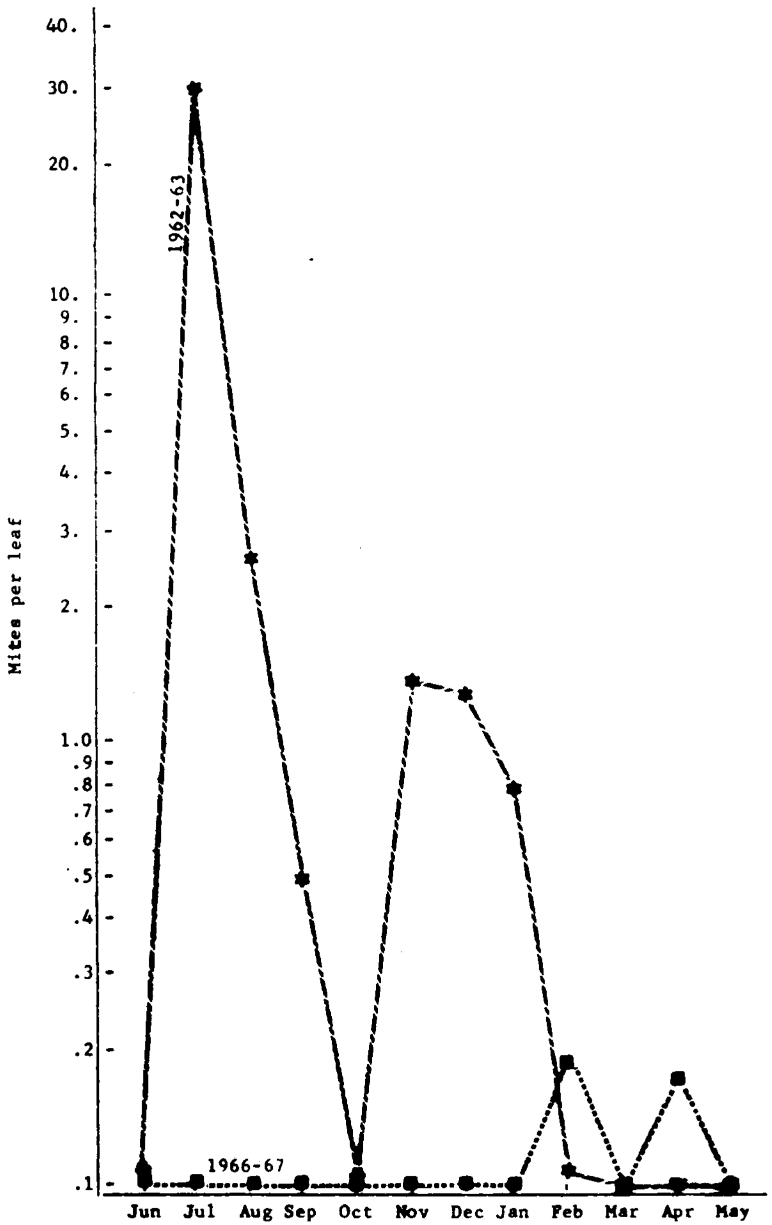

Figure 5. West valley: mean populations of rust mites.

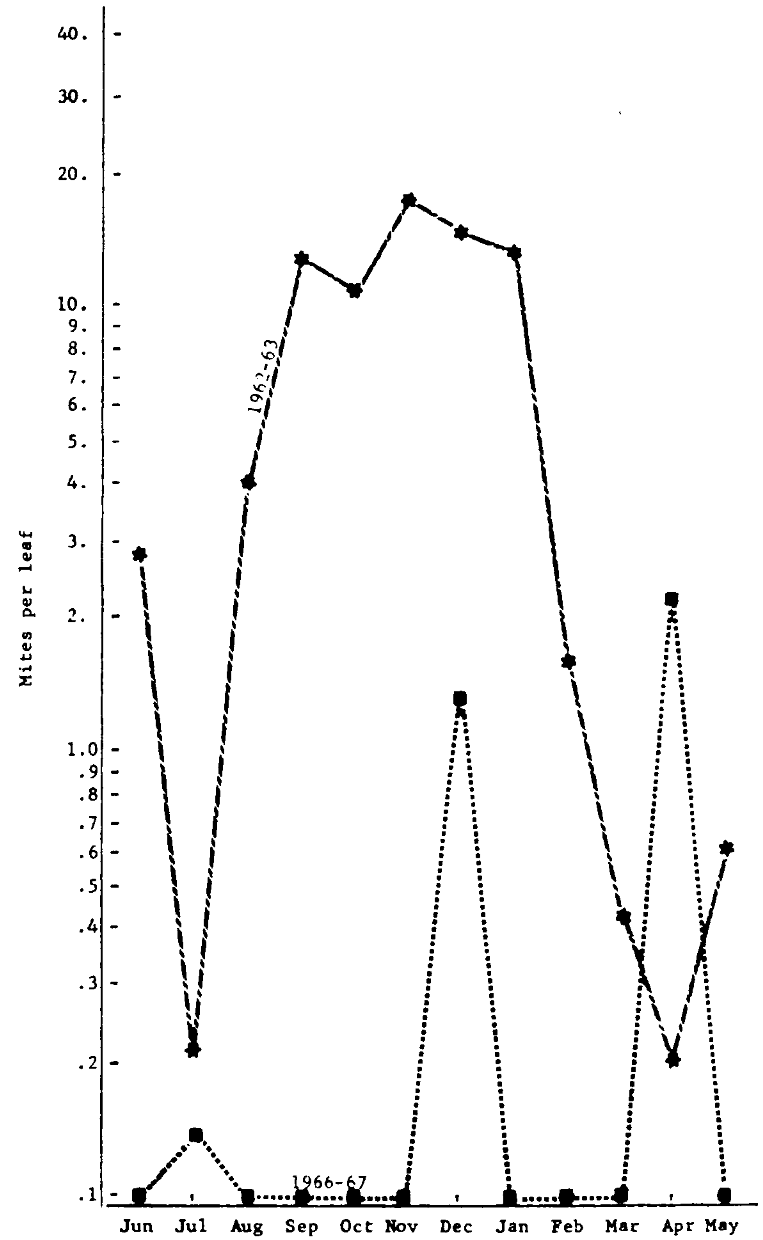

Figure 6. Mid valley: mean populations of rust mites.

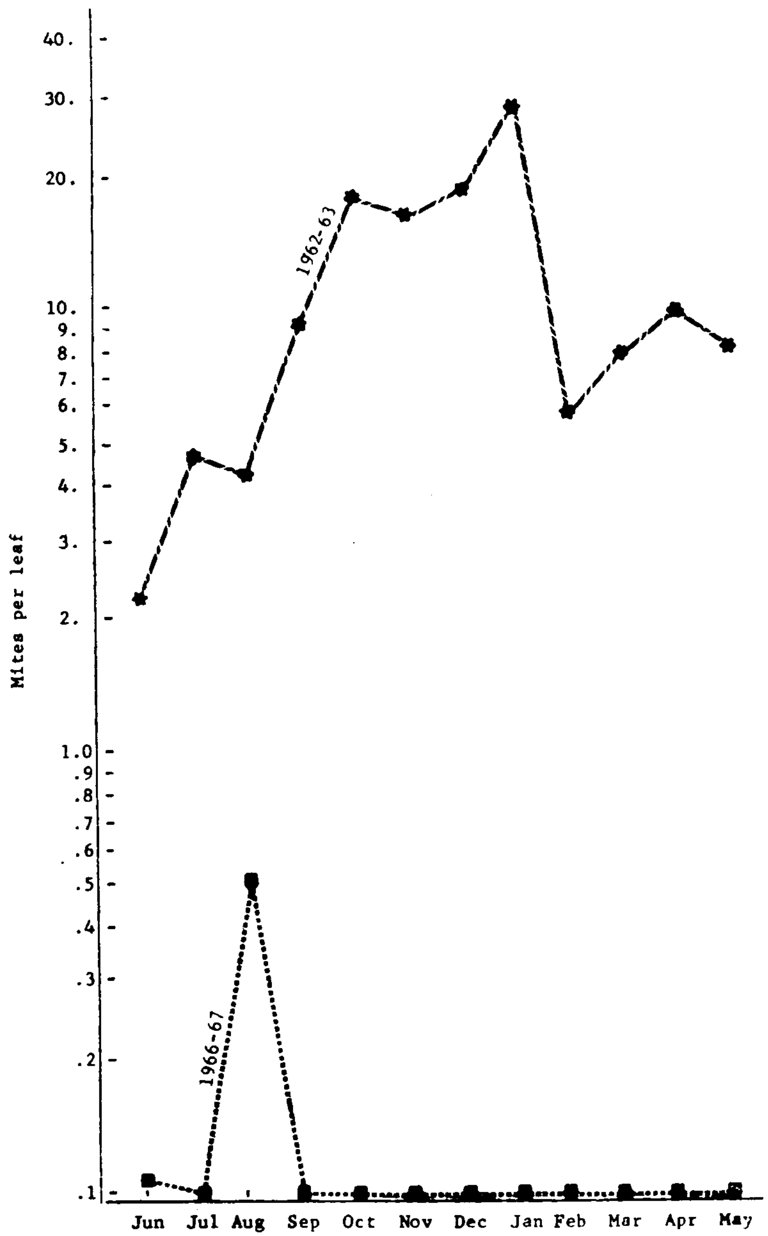

Figure 7. East valley: mean populations of rust mites.

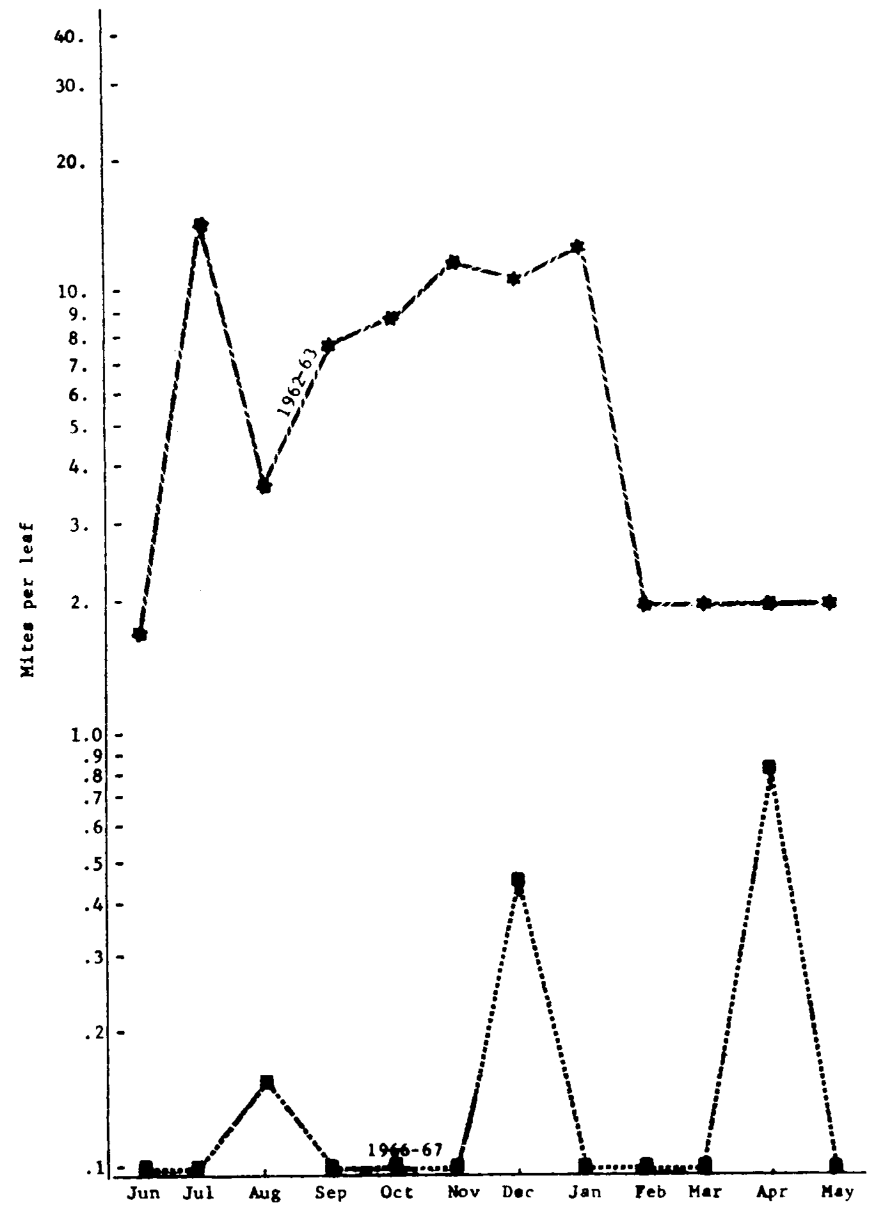

Figure 8. Entire valley: mean populations of rust mites.

Miscellaneous mites. Counts taken of other species of mites are not presented graphically since very low numbers were encountered in both surveys. Survey methods were not designed to take these mites, but counts may be indicative of very general trends in populations.

Low populations of *Brevipalpus* sp. were normally encountered in both surveys, although they were slightly higher in 1966. Highest numbers occurred between September and December in both 1962 and 1966. Highest populations were recorded from mid Valley groves where the greatest number, 0.92 mites per leaf, were recorded in October 1962. All other counts in both surveys were under 0.50 mites per leaf.

Tydeus sp. were much more evident in the 1962-63 survey with populations of over 1 mite per leaf being common from June to October and decreased numbers from October to May. *Tydeids* were somewhat rare in the 1966-67 counts averaging only 0.02 mites per leaf throughout the year.

Phytoseiids, though considered important biological control agents, were not taken in numbers in either survey. Mean averages were 0.041 mites per leaf in 1962-63 and 0.047 mites per leaf in 1966-67. These low counts do not detract from the importance of these mites as effective predators but do indicate the inadequacy of leaf brushing methods for survey of such active mites.

DISCUSSION

Surveys of mites present on citrus in the Rio Grande Valley in 1962-63 and 1966-67 indicate that Texas citrus mite and citrus rust mite populations were much greater immediately after the 1961-62 freeze than 4 years later. Populations of *Brevipalpus* sp. and phytoseiids were about the same both years, but *Tydeus sp.* were more prevalent in the 1962-63 survey. The greater numbers of Texas citrus mites and citrus rust mites in 1962-63 could be due to several factors about which we may only speculate now. Tree condition could be a major factor, but weather conditions and variations in pesticide applications could also be important. For example, several groves had received applications of carbaryl for control of brown soft scale in 1962, and in groves where a miticide had not been included in this application, increased numbers of Texas citrus mites were apparent the following month.

CONCLUSION

These surveys indicate the variable nature of mite populations in citrus groves in the Rio Grande Valley and point to the need for constant vigilance from month to month and year to year. Conditions may so change that a particular mite that was not a problem in the past at specific seasons can become a problem either in isolated groves or throughout the area.

ACKNOWLEDGEMENTS

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co, in these investigations is gratefully acknowledged.

The authors also thank M. Garza, M. Mata, and R. Garcia, Agricultural Research Aids, Entomology Research Division, USDA, Weslaco, Texas, for their field assistance.

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Evaluation of Some Spray Oils Used on Citrus in Texas[1]

Rex B. Reinking[2]

Abstract. Spray oils commercially available in Texas were applied to grapefruit and orange trees in order to compare effectiveness in controlling insects and mites and affect on yield, internal fruit quality and leaf drop.

Significant differences in scale control on oranges resulted with all oils over the non-oiled check. One of the oils did not provide significant differences in scale control on grapefruit. Three of the oils gave significantly greater scale control than the other oils on both oranges and grapefruit.

A significant difference in leaf drop resulted from application of one of the oils on orange trees.

No significant difference was found in acidity or total soluble solids in juice of oranges or grapefruit due to spray oil applications.

INTRODUCTION

The use of citrus spray oils in the Lower Rio Grande Valley of Texas has increased greatly in the past 10 years. This has been due primarily to: the ineffectiveness of conventional dusting equipment in the control of soft and armored scale insects; the effectiveness of spray oils in controlling Texas citrus mites; and the economy of oil in the spray mixture.

Oils in the spray mixture applied to citrus fruit and trees cause a physiological response that may or may not be deleterious (2). Oils may cause oil spotting, leaf drop or fruit drop, and may adversely affect sugar, acid, and juice content of the fruit (1, 4).

The physiological effects of spray oils on citrus trees can be confounded by the microclimate of the orchard during and immediately following spray oil application. Temperatures above 90 F and below 32 F, relative humidity below 20%, and soil moisture stress are factors that can increase the likelihood of tree or fruit injury following spray application. The properties of spray oils that give control of insects and mites are in part the same properties that can cause harmful effects to the tree and fruit (3).

In the spring of 1966 a study of the citrus insect and mite control and phytotoxic effects resulting from applications of citrus spray oils commercially available in the Lower Rio Grande Valley of Texas was initiated. Factors to be evaluated were: control of armored scale, brown soft scale, Texas citrus mites, the incidence of leaf drop following application, the effect of spray oil on internal fruit quality, and total yield. This paper is a report of the first year's results of this work.

[1] Cooperative citrus research of Texas A & I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.

[2] Ass't. Prof. of Agriculture, Texas A & I University Citrus Center, Weslaco.

[3] The author gratefully acknowledges the services of the Shell Oil Company and Humble Oil Company laboratories in determining specifications of oils used.

MATERIALS AND METHODS[3]

Five spray oils available commercially were obtained from local distributors. These were Orchex 796, Oil-I-Cide 80, Oil-I-Cide 99, Shell 210, and Volck Soluble. Duplicate samples of each oil were taken for analysis at 2 laboratories to determine properties outlined in Table 1.

Applications of spray oils were made to 3-year-old Marrs orange and 16-year-old Redblush grapefruit trees. A non-sprayed check was included as one of the treatments. A randomized complete block design, with 4 replications and 1-tree plots was used.

Sprays were applied to oranges March 30 (1.0% oil), July 1 (1.5% oil), and September 27 (0.5% oil); to grapefruit April 5 (1.0% oil), July 6 (1.5% oil), and September 27 (0.5% oil). Minimum and maximum temperatures and humidities on dates sprayed are shown in Table 2.

Texas citrus mite populations were determined by collecting 20 mature leaves from each plot, brushing the mites from the leaves onto counting plates with a Henderson-McBurnie mite-brushing machine, and counting the mites at 20X under a binocular microscope.

Armored scale were counted on a 50 fruit sample from each plot.

Leaf drop was determined by counting the leaves that fell inside a wire cage constructed around the entire tree at the drip line. Nine counts of leaf drops were made on oranges: April 20, June 1, June 29, July 8, July 15, July 27, August 5, August 10, and August 22. Four counts of leaf drop were made on grapefruit: July 12, August 5, August 12, and August 22.

Juice samples for analysis of total acidity and soluble solids were taken at 15-day intervals between September 15 and December 1. The samples were composed of 6 fruit taken from each plot.

Fruit was harvested and yield recorded on December 15, 1966 for the oranges and January 4, 1967 for the grapefruit.

RESULTS AND DISCUSSION

Analyses of the oils used in the test are shown in Table 1. There was some variation in the results of the analysis of the same oils between the two laboratories.

No Texas citrus mite or brown soft scale infestations developed on any of the plots in 1966.

Table 1. Analysis of five commercial citrus spray oils by two laboratories.

Oil Properties	*Volck Soluble* Lab A	*Volck Soluble* Lab B	*Shell 210* Lab A	*Shell 210* Lab B	*Oil-I-Cide 80* Lab A	*Oil-I-Cide 80* Lab B	*Oil-I-Cide 99* Lab A	*Oil-I-Cide 99* Lab B	*Orchex 796* Lab A	*Orchex 796* Lab B
Unsulfonated Residue %V	94.0	91.1	97.4	93.9	96.2	–	93.6	92.1	97.4	92.1
Pour Point, C	+25	+15	+10	+10	+25	–	+25	+20	+10	+5
Neutralization Value, C	0.64	1.3	0	−0.01	0.016	–	−0.019	−0.01	0.022	0.05
A.P.I. Gravity @ 60 F	33.6	33.6	32.1	32.2	34.6	–	37.1	·37.3	35.3	35.1
Viscosity, SSU @ 100 F	95.2	95	103.4	103	67.8	–	50.8	50	74.9	75
Distillation @ 10 mm reduced pressure										
50% point F	483	464	466	456	434	–	398	366	454	428
10-90% range F	86	96	80	64	124	–	126	121	93	103
Distillation by Gas Chromatograph method										
50% point F	475	–	472	–	436	–	404	–	453	–
10-90% range F	135	–	125	–	145	–	152	–	130	–
Ave. Molecular Weight	364		350		316		280		330	

Differences in armored scale control with Volck Soluble, Shell 210, and Orchex 796 were significant over Oil-I-Cide 80, Oil-I-Cide 99, and the check in both oranges and grapefruit (Table 3). All oil treatments were significantly better than the control except Oil-I-Cide 80 in the grapefruit block. Volck Soluble, Shell 210, and Orchex 796 have heavier molecular weights than Oil-I-Cide 80 and Oil-I-Cide 99 and may be expected to exhibit more insecticidal activity.

There was no significant difference in leaf drop between treatments and check in the grapefruit block. Only Orchex 796 oil exhibited a significantly greater difference in leaf drop than the check in the orange plots.

In the juice samples analyzed the differences in soluble solids between treatments and checks were not significant at any sampling date in either grapefruit or oranges (Table 4). Grapefruit in the check plots did not reach and maintain legal minimum soluble solids requirements until November 28 and by then all treatments had reached the 9.0%, required by Texas laws. In the orange plots all treatments except Volck Soluble had reached minimum requirements of 8.5 by October 1. On October 16 all treatments and checks had reached minimum soluble solids to pass Texas maturity standards (5).

Differences in total acidity were not significant between any treatments. Other investigators have found similar results (3, 4).

Yield of grapefruit did not differ significantly among treatments. Yield of oranges was greater from plots sprayed with Oil-I-Cide 80, Oil-I-Cide 99, and the check than from plots sprayed with the 3 other oils. Differences were significant at the 5% level.

Table 2. Maximum and minimum temperatures and relative humidities recorded on dates in 1966 when spray oils were applied.

	Temperature Maximum	*Temperature* Minimum	*Humidity* Maximum	*Humidity* Minimum
		ORANGES		
March 30	76°	58°	100%	26%
July 1	92°	68°	100%	24%
September 27	100°	73°	100%	25%
		GRAPEFRUIT		
April 5	77°	52°	100%	42%
July 6	91°	74°	100%	68%
September 27	99°	72°	100%	25%

Table 3. Mean effect of spray oils on armored scale, leaf drop, and yield in 1966.

Treatment	*Armored scale (per fruit)* Grapefruit	Orange	*Leaf drop[a] (per tree)* Grapefruit	Orange	*Yield (lb per tree)* Grapefruit	Orange
Volck Soluble	57 ab*	10 a	1,698 a	6,056 ab	380 a	59 d
Oil-I-Cide 80	112 cd	34 b	1,793 a	6,028 ab	372 a	115 abc
Oil-I-Cide 99	90 c	44 b	2,019 a	5,890 ab	372 a	136 a
Orchex 796	47 a	10 a	2,389 a	8,184 b	304 a	83 bcd
Shell 210	45 a	15 a	2,262 a	6,808 ab	274 a	72 cd
Check	140 d	155 c	2,035 a	3,781 a	285 a	123 ab

a Leaf drop is the mean of 4 dates for grapefruit and 9 dates for oranges.

* Means bounded by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.

Table 4. Effect of spray oils on soluble solids in 1966.

	Soluble Solids								
	Grapefruit					*Oranges*			
Treatment	*9/19*	*10/7*	*10/31*	*11/14*	*11/28*	*9/15*	*10/1*	*10/16*	*11/1*
Volck Soluble	8.4*	8.9	8.9	8.7	9.3	7.9	8.4	8.9	8.7
Oil-I-Cide 80	8.6	9.0	9.2	8.9	9.3	8.4	8.7	9.0	9.3
Oil-I-Cide 99	8.4	9.0	9.0	9.0	9.1	8.4	8.5	8.9	9.2
Orchex 796	8.3	8.8	9.1	8.8	9.3	8.2	8.7	8.9	9.0
Shell 210	8.4	8.9	8.9	8.8	9.2	8.3	8.7	8.9	9.0
Check	8.5	8.8	9.0	8.8	9.2	8.2	8.8	8.9	9.5

* There were no significant differences between means at the 5% level according to Duncan's multiple range test.

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Spotting of Grapefruit as Associated with False Spider Mites[1]

H. A. Dean and Norman P. Maxwell[2]

Abstract: Large populations of false spider mites, *Brevipalpus californicus* (Banks) and *B. phoenicis* (Geijskes), were associated with a rind spotting of grapefruit during the June-October period of 1966. The "leprosis-like" spotting was found only on fruit that had large populations of these mites. Spots appeared as irregular-shaped, brownish blemishes which varied in size from 1 to 30 mm or larger. The spotted condition appeared first on fruit near the trunk of the tree. False spider mites were found to be more numerous on leaves collected from the inside portion of the trees where the first spotted fruit were found. Dicofol (Kelthane) gave excellent control of these mites and no increase in mite population occurred where oil was used in the pest control program. Azinphosmethyl (Guthion) gave some initial control, but the mites increased to large numbers after application of this material.

A serious rind spotting of grapefruit was found in many Valley groves in the summer of 1966. No pathogenic fungi were found associated with the spotting on grapefruit brought to the Station in late June[3]. The only pests found on any of the fruit were false spider mites. When observed in the grove, false spider mites were concentrated in large numbers in the spotted areas. An investigation was initiated to determine the relationship, if any, between false spider mites and the "leprosis-like" spotting.

Spots appeared as irregular-shaped, brownish blemishes which varied in size from 1 to 30 mm or larger (Figure 1). Each spot contained an aggregation of small spots seemingly fused together in certain instances. The small spots were seldom found in the oil glands of the flavedo of the rind. Spots were found in the oil glands as the concentration of spotting increasing. Spotting occurred on all portions of the fruit. When large areas of spotting occurred, these areas were generally concentrated on the sides and stylar end of the fruit. Spots were generally level with the surface of the peel. Grapefruit were brought to the laboratory from time to time during the January-May period. After 5 days or more, the spotted areas tended to be raised and became darker in color.

False spider mites (the most obvious suspect) were collected from spotted areas on grapefruit at 4 locations. Mites from a grove at Edinburg and Sharyland were identified as *Brevipalpus californicus* (Banks) while those from a grove at Donna and Weslaco were identified as *B.*

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[1] Technical Contribution No. 5994, Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas.

[2] Associate Entomologist and Associate Horticulturist, Lower Rio Grande Valley Research and Extension Center, Weslaco, Texas.

[3] Thanks are due Dr. Bailey Sleeth, Plant Pathologist emeritus, Lower Rio Grande Valley Research and Extension Center, Weslaco, Texas, for pathology examination and determination.

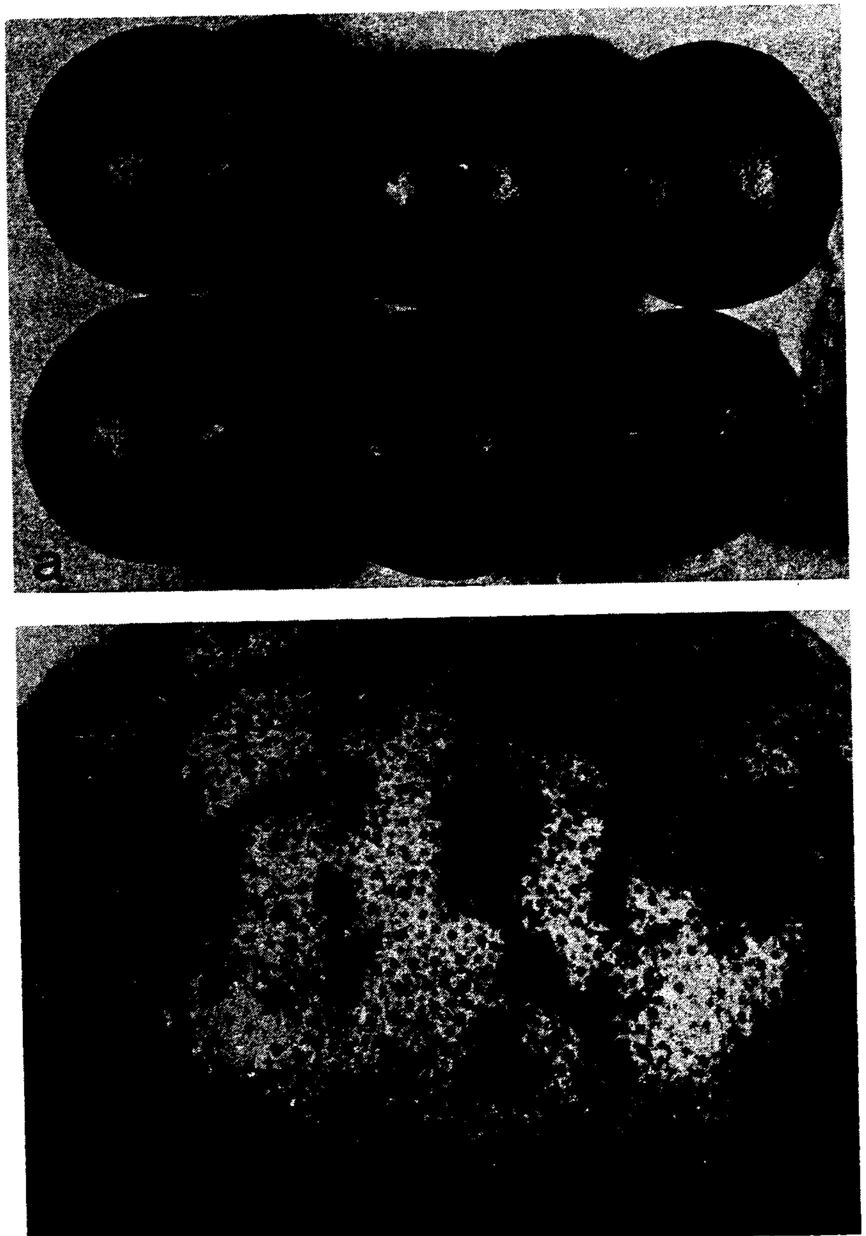

Figure 1. a. Spotting of grapefruit associated with false spider mites.
b. Variations in size of spots, approximately IX.

californicus and *B. phoenicis* (Geijskes)[4]. Previous identifications have shown the above species from the Rio Grande Valley area (3). Terminal flush leaves had greater numbers of false spider mites during the latter 6 months of 1954-56 and in the west quadrants (2,3).

The life history of *B. californicus* was investigated on leaves of orchid (*Epidendrum cochlestum*) seedlings in Maryland (13). Lengths (in parts of an inch) were given for the following stages: egg and larva 1/254, protonymph 1/136 and deutonymph 1/103 (the latter stage about the same size as the adult). Development was completed in 30 days.

Large numbers of false spider mites have been observed on fruit in prior years. However, the concentration of large numbers in any given area, whether a blemish was present or not, has not been observed. During the 2 years prior to 1966, some spotting of grapefruit was noted at Monte Alto and northwest of Edinburg where no chemicals had been applied during the year, and false spider mites were commonly observed. However, some grapefruit trees from 4 to 15 years old were observed during the same 2-year period without evidence of fruit spotting even though no chemicals had been applied since planting.

Blemishes on citrus attributed to *Brevipalpus* mites have varied in different citrus areas. *B. phoenicis* was reported to be involved with halo scab on sour orange foliage in Venezuela (10). Also it was reported to be associated with *Brevipalpus* gall in Venezuela (12) and to be responsible for diffuse chlorotic spotting of citrus foliage in Florida (7). Florida scaly bark and "lepra explosiva" in Argentina were found to be the same disorder and leprosis was proposed as a name for the synonymous disorder easily eliminated by chemical control of *Brevipalpus* mites (9). *B. californicus* has been shown to cause leprosis disease on sweet orange in Florida (6) and to cause brown speckling of flavedo of sweet orange fruit in Spain (14). There have been no indications of serious injury to citrus trees or fruit by *B. californicus* in California but the citrus flat mite, *B. lewisi* (McGregor), produces corky, scab-like spots resulting in a lower grade of fruit (5). Peak populations of the latter mite were reached in the warmest months.

Zineb, applied as a spray or dust, resulted in little to no control of *Brevipalpus* mites in the early work with this material in the Rio Grande Valley area (4). Dicofol (Kelthane) produced the most outstanding control. False spider mite infestations were recognized as a potential problem if zineb was used without the addition of some controlling agent in the grower pest control program (1). In Florida, infestations of *B. phoenicis* were reported to increase following zineb application to privet (*ligustrum lucidum*) and the possibility of false spider mites increasing on citrus was implied (7). Zineb was also shown to be inefficient in the control of leprosis in Florida (8).

[4] Acknowledgement is due Dr. E. W. Baker, Insect Identification and Parasite Introduction Research Branch, Entomology Research Division, U. S. Department of Agriculture, Beltsville, Maryland, for mite identification.

Various workers have reported false spider mites to be controlled easily with certain chemicals. In California, the citrus flat mite was controlled best with dicofol and chlorobenzilate (5) while sulfur dust or spray is also listed in the 1966-67 Treatment Guide from California. In Florida, wettable sulfur effected the most economical control of *Brevipalpus* mites (11). Previous work in the local area has shown the *Brevipalpus* mites have not been a problem when the following materials were used at some time during the season: dicofol, chlorobenzilate, oil or sulfur.

MATERIALS AND METHODS

Spray materials were applied from a ground rig to grapefruit trees at the Sharyland experiment. Coverage was accomplished by use of single nozzle guns at 550-600 psi, spraying in quadrant positions from the ground and from a tower gun above the tree tops. Trees were sprayed at Weslaco with the same conventional ground rig without the use of the tower gun. Grapefruit trees were sprayed with 500 gallons per acre at the Donna grove with a ground rig using a single gun directed into the tree from a stand on the sprayer and a single gun directed into the tree from the ground. Application was made at the Drake and Bogue groves by fixed wing airplane at the rate of 8 gallons total liquid per acre. The latter groves were sprayed principally for control of Texas citrus mites, *Eutetranychus banksi* (McGregor), but false spider mites were also present.

Mite populations were determined at 6 different locations in the Drake and Bogue groves. Each 40-leaf sample consisted of 2 leaves from each quadrant of 5 trees. The same type sample was taken at 4 locations at the Sharyland grove and at 2 locations at the Donna and Weslaco groves. Portions of the tree from which leaf collections were taken were designated as follows: Upper–5 to 7 feet above the ground, Lower–0 to 2 feet above the ground, and Inside–2 feet or more from the exterior of the tree about waist high. Mites were brushed from the leaves with a mite-brushing machine onto a 5-inch plate where they were counted on ½ the area with a stereoscopic microscope.

Formulations of the various materials applied from ground equipment were as follows: 22.2% E azinphosmethyl (Guthion), 50% E chlorobenzilate, 18.5 and 42% E dicofol (Kelthane), 46.5% E ethion, Oil (412 and 448° F – 50% distillation temperature at 10mm Hg.), 12.3% E tetradifon (Tedion), and 75% WP zineb.

RESULTS

Fruit from the inside portion of the tree were the first to show the spotted condition. Exterior fruit became spotted as the population of false spider mites increased. Mite populations have previously been determined from only terminal flush leaves in the local area. The sampling method was revised to determine the abundance of false spider mites on leaves from the upper, lower and inside portions of the tree.

Spotted grapefruit and populations of false spider mites were more prevalent in the Donna grove than at other locations where mite populations were determined. Pre-treatment counts were made only in the ethion-azinphosmethyl plots (Table 1). The grower applied various treatments for control of Texas citrus mites in such a manner that much useful information could be gathered by taking population counts of all mites present in the grove. Field inspection had shown that false spider mites were very common throughout the entire grove. Leaves from the inside of the trees had larger populations of false spider mites than those collected from the tops of the trees. Greater numbers of mites were found in plots treated with azinphosmethyl (Guthion) alone or with zineb than in other places. After the December 3 count, false spider mites were almost eradicated from the dicofol-azinphosmethyl (Guthion) plots which supports previous findings that dicofol (Kelthane) is very toxic to these mites. Counts on December 3 indicates that ethion may have given some initial reduction in false spider mites. Reduced populations were found in all plots during the January-March period. Mites had increased in all plots by April 11 except in the dicofol-azinphosmethyl and non-treatment plots. Populations remained about the same in the non-treated plots where 2, 6 and 15 phytoseiid (beneficial) mites per 40 leaves were found on the last count date in the upper, lower and inside portions of the trees, respectively. Only 7 phytoseiid mites were found in all samples from the non-treated trees until the last record in April. Only 1 phytoseiid mite per 40 leaves was found in some samples in the treated trees on April 11, but none were found prior to that date. The increase in numbers of phytoseiid mites was indicative of their possible importance in control of false spider mites. The false spider mite egg populations were not shown in the table, but their numbers were usually about the same as the mite population or greater.

Small populations of false spider mites were found at the Drake grove north of Weslaco before application of dicofol (Kelthane) from a fixed wing airplane (Table 2). Spray coverage was considered to be poor on inside leaves with this type of application even though general wind movement was only 0 to 3 mph at the time of application. Although mites were not counted from the lower and inside portions of the trees until after application, false spider mites were less abundant on leaves collected from the upper portion of the trees and more abundant on leaves collected from the interior portion of the trees. Phytoseiid mites were also more abundant on inside leaves. False spider mites remained in extremely small numbers after the December counts.

Before application of ethion from a fixed wing airplane, the initial populations of false spider mites were slightly smaller at the Bogue grove north of Monte Alto (Table 3) than at the Drake grove. General wind movement was 0 to 3 mph at the time of application; so, coverage was probably better than might have been expected under windier conditions. False spider mite populations declined somewhat in late December but by March had almost reached the pre-treatment level. Generally, false spider mites and phytoseiid mites were more numerous on

Table 1. False spider mites per 10 leaves in different portions of the tree following various chemicals applied in a grove just west of Donna, Texas, during 1966-67 season.

Date	U[1]	L[2]	I[3]	U	L	I	U	L	I	U	L	I	U	L	I
10-21	28.0	100.0	96.0												
11-10	½ gal ethion + 1 gal azinphosmethyl			1 gal azinphosmethyl + 5 lb zineb			1 gal azinphosmethyl			1 gal azinphosmethyl + 1 gal 18.5% dicofol			None		
12-3	12.5		12.0	88.5		78.0	132.0		123.0	18.0		55.0	50.5		42.5
1-17	1.2	3.8	5.8	2.0	10.8	29.0	3.5	13.2	31.8	0.0	.2	.2	13.5	6.8	19.5
2-13	0.0	1.0	6.0	.8	1.8	12.0	3.2	6.5	14	0.0	0.0	0.0	5.0	4.2	6.2
3-17	3.2	1.5	4.2	4.5	6.0	13.5	3.5	7.2	13.2	0.0	0.2	0.0	3.8	5.5	11.2
4-11	8.0	10.5	27.0	18.0	13.2	33.0	24.8	17.0	22.0	0.0	0.0	0.0	6.8	2.2	4.8

[1] Leaves collected 5-7 feet above ground.
[2] Leaves collected 0-2 feet above ground.
[3] Leaves collected 2 feet or more from the exterior of the tree.

Dosages of above materials given for 500 gallons per acre.

Table 2. False spider mites and phytoseiid mites per 10 leaves in different portions of the tree following application of dicofol application to citrus by airplane 2 miles north of Weslaco, Texas, during 1966-67 season.

	Brevipalpus mites			*Brevipalpus eggs*			*Phytoseiid mites*		
Date	*Upper*	*Lower*	*Inside*	*Upper*	*Lower*	*Inside*	*Upper*	*Lower*	*Inside*
12-7	3.1			2.3			1.3		
12-8	1	quart	42% E	dicofol	per	acre[a]			
12-14	.7	1.5	3.0	1.4	1.6	3.0	.2	.6	2.6
12-21	.1	1.7	1.7	1.4	3.0	3.4	.2	.2	1.2
1-6	.1	.5	.8	.5	1.3	2.0	0.0	.7	2.0
1-19	0.0	0.0	.01	.01	.01	1.0	0.0	0.0	.3
2-9	0.0	0.0	.01	0.0	0.0	.3	0.0	.2	.2
3-17	0.0	.1	0.0	0.0	.2	.1	.1	0.0	.1

[a] Dosage applied in 8 gallons per acre.

Table 3. False spider mites and phytoseiid mites per 10 leaves in different portions of the tree following ethion application by airplane 1.5 miles north of Monte Alto, Texas, during 1966-67 season.

Date	*Brevipalpus mites*			*Brevipalpus eggs*			*Phytoseiid mites*		
	Upper	*Lower*	*Inside*	*Upper*	*Lower*	*Inside*	*Upper*	*Lower*	*Inside*
12-8	2.3			1.8			1.7		
12-10	1	quart	46.5%	E	ethion[a]				
12-15	2.4	5.8	10.6	2.7	12.3	13.2	.2	1.3	4.7
12-22	2.1	2.5	3.1	5.3	7.1	6.2	.2	.2	.7
1-13	.5	.5	2.7	1.0	2.7	7.3	.1	0.0	.4
1-24	0.0	.8	.5	.2	1.3	2.5	0.0	.3	.3
2-9	.3	.5	1.2	.6	1.5	6.1	0.0	.8	.5
3-10	.7	.7	1.7	.3	1.1	2.1	.1	0.0	.1
4-20	1.7	2.8	4.8	1.4	2.8	3.3	2.5	2.8	3.8

[a] Dosage applied in 8 gallons per acre.

inside leaves. False spider mites were found very readily on some unpicked fruit on April 20.

Consideration was given to the possibility of reducing false spider mite infestations with application of azinphosmethyl (Guthion). Populations varied from 3 to 6 per leaf (Table 4) before application of this material to 4-year old nursery trees that had not been sprayed or dusted for pest control since the time of planting. No spotting of lemons, oranges or grapefruit was found in this nursery. A sharp reduction in false spider mites was noted on November 15. The number of false spider mite eggs on November 15, though reduced, was proportionately much greater than the number of false spider mites. The greatest portion of the mites counted on this date were in the larval stage and no adults were found on November 15 or December 2. Such evidence indicated that eggs were the source for reinfestation following treatment. After the initial reduction of false spider mites, their numbers remained about the same until the March-April period when an increase in population was found. After treatment, phytoseiid mites were found only in the December 2 count. False spider mites were present in small numbers in the untreated trees with a small population of phytoseiid mites in the counts except during the January-February period. The coloration in the alimentary tract of the phytoseiid mites was an indication of feeding on false spider mites and/or their eggs. The importance of these beneficial mites in the control of false spider mites is not well known and plans are underway to further investigate this predator-prey relationship.

During late September 1966, an occasional spotted grapefruit was found in the interior portion of trees receiving 1 particular treatment in an experiment at Sharyland. Plots were randomized in blocks and replicated 4 times. Post-bloom and summer applications were made on April 12 and July 13, respectively. In plots where no spotting was found, false spider mite populations were less than 1 per 100 terminal flush leaves. The following amounts of materials per 100 gallons are given for the 4 different treatments: 1.0% 448 oil plus 1 lb zineb followed by 1.6% 448 oil plus 1 lb zineb, 0.8 pint dicofol (Kelthane) plus 0.5 lb zineb followed by 1.6% 448 oil plus 1 lb zineb, 1.0% 412 oil plus 0.5 lb zineb followed by 1.6% 412 oil plus 1 lb zineb, and 1 quart tetradifon (Tedion) plus 0.8 pint chlorobenzilate followed by 0.8 pint dicofol plus 1 lb zineb. An occasional interior grapefruit was spotted following the April and the July application of 1.5 pint azinphosmethyl (Guthion). Terminal flush leaves in the latter plots showed the following false spider mite and egg populations per 100 leaves on August 29, September 19 and October 17, respectively: 18, 10; 255, 381; and 150, 90. A mixture of dicofol (Kelthane) and zineb was applied to the entire experiment by the grower to avoid increases of various mites. Thereafter, terminal flush leaves usually had only a single false spider mite or so through the April 1967 count date.

Table 4. False spider mites and phytoseiid mites per 10 leaves from 4-year old nursery trees following total coverage spray of azinphosmethyl versus no treatment during 1966-67 at Weslaco, Texas.

Date	*Brevipalpus mites*	*Brevipalpus eggs*	*Phytoseiid mites*	*Brevipalpus mites*	*Brevipalpus eggs*	*Phytoseiid mites*
11-9	64.5	173.4	3.0	32.5	96.0	1.0
11-10	1½ pint 22.2% E azinphosmethyl/100 g				No Treatment	
11-15	.5	24.5	0.0	0.0	7.5	0.0
12-2	7.5	6.0	.5	1.0	1.5	.5
12-7	9.0	3.5	0.0	3.5	2.5	.2
12-13	5.0	2.5	0.0	2.2	1.2	0.0
12-21	3.0	4.8	0.0	1.0	1.5	.2
1-10	1.5	9.2	0.0	0.0	0.0	0.0
1-20	2.0	8.8	0.0	.5	2.0	0.0
2-14	7.0	7.0	0.0	.8	3.2	0.0
3-15	7.8	11.5	0.0	1.8	2.2	.2
4-6	21.6	27.0	0.0	.5	1.0	1.2

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Trithion Spotting of Grapefruit[1]

Rex B. Reinking[2]

Abstract: Trithion, an organic phosphate, was found to cause a discoloration in spoted areas on the peel of Red grapefruit sprayed after August 8, 1966. No spotting was observed on grapefruit sprayed during the month prior to that date. Addition of spray oil to the spray mix did not affect the amount of spotting. Internal quality of the fruit was not affected in fruit sprayed with Trithion.

INTRODUCTION

Trithion (Carbophenothion-O,O-diethyl S-p-chlorophenylthiomethyl phosphorodithioate), an organic phosphate insecticide, may be sprayed on citrus fruits to within 14 days of harvest.

There is renewed interest in this material as an addition to the citrus spray program in Texas because of its effectiveness in controlling brown soft scale, (*Coccus hesperidum* Linn) (1). Trithion is also effective in controlling rust mite, (*Phyllocoptura oleivora* Ash.), and Texas citrus mite, (*Eutetranychus banksi* Pritchard & Baker).

Trithion has an average acute oral LD-50 of 56 mg/kg. and an acute dermal LD-50 of 1270 mg/kg. These ratings indicate that it is only slightly toxic by skin absorption and moderately toxic orally. Material could be sprayed with ground equipment by men without protective clothing. It is readily compatible with oil. The addition of this material to the regular summer application of spray oil could be of benefit in increased control of brown soft scale, Texas citrus mite, and rust mites.

In Florida discoloration has occurred in spots on the peel of grapefruit when Trithion was combined with oil in the summer spray or when applied alone in the fall before the fruit was fully colored (2). Normal coloring processes in the packinghouses did not remove these spots. The spotting did not occur on oranges following Trithion application. Trithion was applied in Texas in the summer of 1966 to determine if and at what time during the season similar spotting might occur on grapefruit.

MATERIALS AND METHODS

Spray applications were made to 12-year-old Redblush grapefruit trees at Weslaco, Texas. Beginning July 12, 1966, two trees were sprayed each week with 4 liquid ounces of Trithion 4E in 50 gallons of water. Three quarts of 96% spray oil were added to the treatment on alternate weeks beginning the second week. The final application was made November 23, 1966.

[1] Cooperative citrus research of Texas A & I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.

[2] Ass't. Prof. of Agriculture, Texas A & I University Citrus Center, Weslaco.

Fruit was collected for examination from all trees on December 15, 1966.

RESULTS AND DISCUSSION

There was no rind discoloration caused by Trithion applications through August 5, 1966. All applications thereafter resulted in the spotting and occasional "tear staining" of some fruit (Figure 1). The addition of spray oil to the Trithion had little or no effect on the spotting.

The spots were hardly noticeable until the rind began to break color late in the fall. The affected areas remained green while the rest of the fruit turned yellow. There was no observable injury to the cells in the rind but rather a retention of the green chlorophyll color in the spots. Fruit placed in degreening rooms in the packinghouse showed no color change in the spotted areas. Green spots remained green.

There was no deleterious affect from the rind spotting on the internal quality of the fruit.

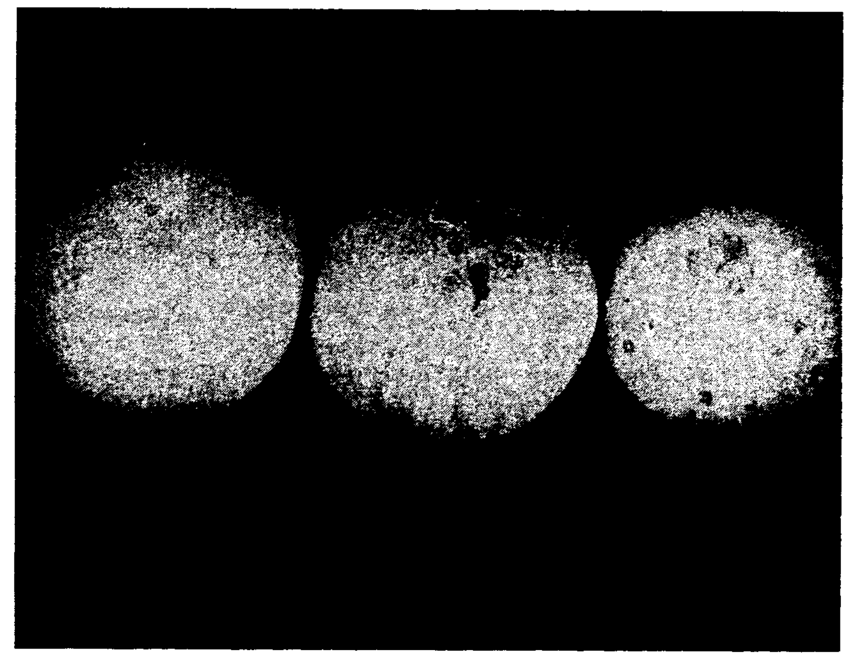

Figure 1. Red grapefruit sprayed with Trithion before August 8, 1966 and two later dates demonstrating discoloration.

Not all of the fruit on the trees was spotted. When spotting did occur, approximately 10-20% of the fruit was affected. The green color of the spots was darkest following the August 8 application and seemed to be less dark on fruit from each application that followed. This may have been due to a smaller amount of chlorophyll in the peel as time went by and therefore not as much green color present to be retained in the spots.

The results of these tests indicate that Trithion could be added to the summer oil spray application if applied to grapefruit before August. Probably the greatest benefit would be from increased residual of control over brown soft scale. Caution should be exercised in not including Trithion in the spray schedule after August as some spotting of grapefruit may occur.

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The Effect of UC-21149 on Infestations of Brown Soft Scale[1] on Potted Citrus

W. G. Hart[2] and S. J. Ingle[3]
Entomology Research Division, Agr. Res. Serv., USDA, Weslaco, Texas 78596

Abstract: Soil applications of 10% granular UC-21149 (2-methyl-2-(methylthio) propionaldehyde *O*-(methylcarbamoyl)oxime) effectively controlled infestations of brown soft scale, *Coccus hesperidum* L. on potted citrus seedlings for as long as 20 weeks after treatment. An application of 4 gm. per 5-gallon metal can kept the seedling free of scale from the eighth to the fourteenth week following treatment. Parasites were present as long as scales were found in significant numbers.

INTRODUCTION

Since the outbreak of brown soft scale, *Coccus hesperidum* L., first occurred in the Rio Grande Valley in 1959 (1), control methods have consisted primarily of applying oil or organophosphate or carbamate insecticides. Oils have not always been entirely effective, but the organophosphate and carbamate insecticides have provided adequate control. However, these insecticides have been associated with upsurges of other pests that may be related to the destruction of beneficial species in the Rio Grande Valley and in other citrus-producing areas. Thus their use requires careful timing and application of treatments. Tests of newer materials now include the evaluation of systemic compounds by various treatment methods for control of the scale. The present paper reports a greenhouse test with UC-21149, (2-methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl) oxime), a systemic insecticide, to control the brown soft scale on potted citrus.

MATERIALS AND METHODS

Grapefruit seedlings, 18 inches high in 5-gallon metal cans, were infested with brown soft scale by dusting crawlers on the leaf surfaces. When the scales were mature (about 35 days old), total counts were made of the number of established scale seedling. Then 2, 3, or 4 gm. of 10% granular formulation of UC-21149 was worked into the soil surface of the potted citrus. A fourth plant was retained without treatment. After application of the material, the seedlings were thoroughly watered and placed in a greenhouse where the mean daily temperature was maintained between 70 and 89°F., and the relative humidity ranged between 50-95%. Since other citrus plants in the greenhouse infested

[1] *Coccus hesperidum* L. (Hemiptera: Coccidae).
[2] Research Entomologist.
[3] Agricultural Research Technician.

with brown soft scale supported 2 active parasites, *Coccophagus lycimnia* (Walker) and *Microterys flavus* (Howard), the test plants were at all times subject to reinfestation and parasitism.

Weekly counts of the total number of scales on each seedling were made. Observations were also made of the impact of the pesticide on the two parasites.

RESULTS

Application of 3 and 4 gm. of 10% granular UC-21149 to potted citrus caused a sharp decline in the populations of scale 2 weeks after treatment (Table 1). By 8 weeks post treatment, the plant treated with 4 gm. had no live scale, and the population on the plant treated with 3 gm. had been reduced 98.4%. During the same interval, populations on both the control and the plant treated with 2 gm. increased sharply. The population of the control plant, after fluctuating markedly, showed a 127% increase by the eighth week; the population of the plant treated with 2 gm., after reaching its peak at 4 weeks, was still 6.3 times higher than the pretreatment level at 8 weeks. Thereafter, the population of

Table 1. Effect of soil applications of 10% granular UC-21149 on brown soft scale on potted citrus.

Observation interval (weeks)	*Number of scales per treatment*			
	Check	*2 gm.*	*3 gm.*	*4 gm.*
Pretreatment	107	182	308	529
1[a]	39	205	781	492
2	231	611	543	115
3	783	1,437	203	89
4	591	2,324	78	32
5	342	2,144	48	7
6	175	2,088	16	4
7	222	1,407	9	0
8	243	1,154	5	0
9	929	170	3	0
10	1,952	105	2	0
11	3,940	64	0	0
12	5,875	34	0	0
13	5,872	130	0	0
14	6,400	169	9	0
15	9,162	193	14	13
16	14,113	161	27	12
17	15,033	53	4	3
18	19,000+	288	306	49
19	20,000+	2,365	107	96
20	20,000+	2,586	167	210

[a] After treatment.

the control increased rapidly and exceeded 20,000 at 19 weeks. The plant treated with 2 gm. reached its lowest population at 12 weeks and increased thereafter with minor fluctuations. After the plant treated with 3 gm. had been free of scale for 3 weeks, it had a reinfestation at 14 weeks, and the population had a general upward trend thereafter. The plant treated with 4 gm. remained free of scale for the next 7 weeks, but scale recurred the 15th week, and the population then slowly climbed. The control seedling died at 21 weeks because of the infestation. After 24 weeks, the plant treated with 4 gm. had about the same level of infestation that it had before treatment.

The parasites that were parasitizing 3.9% of the scales at the time of treatment continued to appear throughout the test in the scale population treated with UC-21149 except for 5 weeks when the population of scale was at its lowest level. When the population of scale increased above 200 per seedling, the parasites reappeared and increased as the population increased. During the decline of parasitism on the treated trees, the parasites on the control also declined. When the effects of the systemic insecticide diminished, the scale recovered rapidly, and a sharp increase in parasitism occurred. On the treated trees, 5.9 and 6.8% of the scale were parasitized 21 and 22 weeks after treatment; no parasitism was evident 7 weeks earlier.

DISCUSSION

Soil applications of the systemic insecticide UC-21149 in granular form offer promise for control of brown soft scale on citrus. This pesticide demonstrated lengthy residual effect and minimum harm to the most abundant species of parasites occurring in the Rio Grande Valley area. Since the technical material has an oral LD^{50} of 1 mg. per kg. of body weight, it must be considered among the more toxic pesticides available and must be handled with extreme caution because of this high mammalian toxicity. Before it can be considered for use in groves, the field effectiveness must be evaluated, tolerance levels must be established, and residue characteristics must be determined. Evidence obtained in these studies indicates that early pursuit of these objectives is warranted.

ACKNOWLEDGEMENTS

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The Influence of Cultural Practice on the Response of Grapefruit Trees to a Sequence of Early and Late Season Freezes[1]

J. E. Fucik[2]

Abstract: During the winter of 1966-67 mild freezes occurred in early December and February in the Texas citrus area. Leaf loss from the December freeze was 30% greater on trees growing in the colder sod plots than on those in either the chemical weed control or mechanically cultivated plots. When the February freeze occurred, the trees in the sod plots, whose shoot growth was much advanced over the other trees, had 61% of the shoots frozen compared to 5 and 10% in the cultivated and chemical plots. The effects of these freezes resulted in a tenfold reduction in fruit set on the sod trees.

INTRODUCTION

On nights of radiational freezing citrus orchards in a system of chemical weed control with no tillage may be 2 to 4 F warmer than adjacent orchards in sod or mechanically cultivated culture (7). Leyden (6) has shown this temperature differential can result in a yield advantage for the orchard in chemical weed control where either severe or mild freezes have occurred. During the winter of 1966-67, a radiational freeze with 24-26 F minimum temperatures occurred December 12. After 6 weeks of generally cool days and nights followed by 2 weeks of warm weather, temperatures dropped to the mid-twenties on February 9. The early-late sequence of these freezes produced an injury pattern which again demonstrated how the higher temperatures associated with chemical weed control can be of considerable practical importance.

MATERIALS AND METHODS

The Redblush grapefruit trees used in this study were located in the two cultural practices experimental plots at the Texas A & I University Citrus Center, Weslaco. The cultural practices are chemical weed control with no tillage, mechanical or clean cultivation, and sod cover crop. The trees in one orchard were planted in November, 1952 and in the other June, 1960. In both locations, however, the trees were frozen back in 1962.

Chemical weed control has been achieved primarily with diuron plus spot spraying with weed oil. Cultivation was performed with standard tractor-drawn, tillage implements. The sod is mainly bermuda and johnsongrass intrespersed with other native grasses and weeds.

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[1] Cooperative citrus research of Texas A & I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.
[2] Ass't. Prof. of Agriculture, Texas A & I University Citrus Center, Weslaco.

Freeze injury was largely confined to new-growth leaves and tender young shoots. Damage was assessed by determining the percent of leaves lost or shoots frozen. For the leaf and shoot counts one branch of 50-100 leaves on the north, east, south, and west side of each tree was randomly selected for counting. For the fruit set counts, two branches of 200-300 leaves apiece were picked from each quadrant making a total of eight branches per tree. In all, 18 trees, three per cultural practice for each of the two plot locations, were used.

Statistical analyses and correlations were performed according to standard procedures (5).

Temperatures were recorded with minimum registering thermometers in a 5 ft. inverted "L" stand. Values are the means of six readings.

RESULTS AND DISCUSSION

Table 1 contains the minimum temperatures recorded in the three cultural practices on the relevant dates. The near-identical behavior of the chemical and cultivated plots can probably be accounted for by their similar vegetation-free and physically smooth surfaces. This latter condition was primarily the result of irrigating after the last cultivation in the cultivated plots. When cultivated plots are rough-surfaced due to recent tillage or have heavy weed growth, they are usually colder than chemical weed control plots (6, 7). The difference between the chemical and sod plots while less than normally measured was consistent with past observations. Other records indicated temperatures were at or near these minimums between 1 and 2 hours.

The average day/night temperatures for the week preceding December 12 were 81/66 F. Young and Peynado's work (9, 10) indicated several weeks of day/night temperature of 70/50 F and lower were needed to substantially increase cold hardiness in Redblush grapefruit. They found exposing unhardened trees to 4 hours of 24 F compared to 25 F increased defoliation from 50 to 95%. Defoliation resulting from the December 12 freeze was significantly greater in the colder sod plots than in the bare-surface plots (Table 2). The difference between chemical and cultivated was not significant.

Other responses of the trees defoliated in December are also shown in Table 2. The heavy defoliation followed by the warm weather in late

Table 1. Minimum temperatures (F) recorded on December 12, 1966 and February 9, 1967 in grapefruit orchards under three cultural systems, Texas A & I Citrus Center, Weslaco.

	Chemical Weed Control	*Mechnical Cultivation*	*Sod*
December 12, 1966	25.2	25.3	24.2
February 9, 1967	26.1	26.0	24.5

January-early February caused considerably greater shoot growth in the sod culture trees compared to those in chemical weed control or cultivation. The effect of the February 9 freeze on this new growth is shown in the third column of Table 2. As with leaf loss, the chemical and cultivated plots are statistically similar while the 60.8% frozen shoots on the sod trees is significantly greater than the other plots.

The number of fruit set on the test trees is recorded in the last column of Table 2. The almost ten-fold difference between the sod and other plots is highly significant. While either of these freezes could have reduced the following year's yield, their particular early-late sequence apparently combined to produce a more than additive effect. In California, studies related to mechanical harvesting showed navel orange yields were reduced 94, 50, and 30% following 100, 50, and 25% leaf removal (8). If these results apply to leaf loss from freezing, fruit set on the sod trees should have been only 1/3 that on the other trees. One must conclude then that the February freeze also contributed to the reduced fruit set. On mature Valencia oranges in freeze chambers, Hendershott (4) found damage to trees frozen in February and March was proportional to the amount of new growth. While he observed that fruit set was often not affected even when moderate wood injury occurred, he felt the absence of radiation freeze conditions in the cold chamber precluded unqualified comparison to a natural freeze situation. On February 6 a count of the flower buds, on trees in the three cultural plots was made for another experiment. Although the number of identifiable flower buds was quite limited, there were no obvious differences in potential blossoms between plots at this time. What factors, then, combined to produce the major reduction in fruit set on the sod trees?

There is little doubt that the initial leaf loss was sustained because the December freeze occurred before any significant winter dormancy had been induced in the trees. A noteworthy consequence of the December freeze is the effect of leaf loss on subsequent shoot growth, and finally on the number of shoots frozen in Ferbruary. The correlation coefficient between December leaf loss and % shoots frozen in February is .85 which is highly significant. The stimulation of shoot growth following defoliation is a well-known phenomenon. Cooper (1, 2) suggested cambial activity and bud dormancy were probably auxin controlled processes. While he felt auxin produced in mature leaves may induce the cambial activity which usually precedes the loss of winter dormancy, my data suggest the alternative idea that the leaves contain an anti-auxin which suppresses cambial activity and but growth. The loss of this anti-auxin by defoliation would then cause early and rapid shoot growth following the first break in cool temperatures.

A final point of interest concerns the observation that the loss of winter dormancy does not occur simultaneously with bud break but appears to lag behind increased cambial activity and spring growth initiation (11). Even though shoot growth had begun on trees in all three cultural plots by February 9, the length of the new shoots on the sod trees would indicate a much earlier bud break. Because of this lag

Table 2. Effects of early and late freezes on grapefruit trees in three cultural systems.

Cultural Practice	*% Leaf Loss (From Dec. 12 freeze)*	*Avg. Shoot Growth (Feb. 7, 1967)*	*% Shoots Frozen (From Feb. 9 freeze)*	*Avg. Fruit Set/Branch (On Mar. 10, 1967)*
Chemical Weed Control	11.2 a*	.10 cm. a	10.3 a	22.8 a
Cultivated	4.0 a	.23 cm. a	5.2 a	22.1 a
Sod	30.6 b	1.13 cm. b	60.8 b	2.4 b

* Values not having a letter in common are significantly different at the 1% level.

in loss of winter dormancy the trees in the chemical and cultivated plots were undoubtedly still much more dormant than the sod culture trees whose buds had probably broken three to five days earlier. Thus with little cold resistance left and with flower buds already differentiated, the trees growing in sod were especially susceptible to freeze injury and potential yield reduction.

More relative information is anticipated from a current study on whether trees in chemical weed control generally initiate spring growth after those in sod. Surely future investigations of the relationship of auxin to winter dormancy would also provide much additional information to construct the reasons underlying this particular early-late freeze injury pattern.

CONCLUSION

The higher temperatures associated with orchards in chemical weed control or clean cultivation vs. sod culture considerably reduced freeze injury and subsequent effects following the sequence of an early and late season freeze.

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Some Aspects of Growth and Sizing of Redblush Grapefruit[1]

JOHN E. FUCIK[2]

Abstract: The growth of mature Redblush grapefruit was studied for t o seasons from September through mid-April. Fruit weight increased about 4% a w k until January, remained static during February-early March, then increased agai n late March and April. Fruit gained one commercial size class every 5-7 weeks exc t during January-February. The pattern and amount of fruit droppage varied considerably between the two seasons. Fruit of a given size increased in weight throughout the season. The effect of partial picking on the growth of the fruit left on the tree was not consistent for the two years.

INTRODUCTION

The harvesting season for Texas grapefruit, extending from September to June, may include freezing temperatures, dry spells, heavy rains, and high winds. The spring growth flush, bloom, and fruit set will occur during this period. How do weather conditions and physiological activities affect the mature crop? Data is presented regarding growth and size characteristics of the mature fruit over the harvest season.

MATERIALS AND METHODS

Eight Redblush grapefruit trees on sour orange rootstock were used in this study. The trees were located on the NW-SE diagonal of a 12-row-wide cultivated experimental plot at Texas A&I Citrus Center. The trees, planted in 1952 and frozen back in 1962, were about 12 ft. high and had crowns 12 ft. in diameter. Tree spacing was 20 by 22 ft. The trees have been fertilized with 1-1½ lbs. of nitrogen per tree each year since 1955.

Ten fruit in 1965-66 and 12 fruit in 1966-67 on each of four trees were tagged and numbered. The fruit was randomly selected from the region 2-6 ft. high and 0-3 ft. inside the canopy. A sample of 10 (1965-66) or 12 (1966-67) fruit were picked from the remaining trees in the experiment at each sampling date.

From late September through mid-April the diameter of the tagged fruit was measured every two weeks. The value recorded was the average of two measurements made perpendicular to each other at the point of maximum diameter. The diameter and the weight of each fruit from the picked sample was obtained within 24 hours of picking. In 1966-67 the height of the fruit was also measured and the volume of

[1] Cooperative citrus research of Texas A & I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A & M University, Weslaco.

[2] Ass't Prof. of Agriculture, Texas A & I University Citrus Center, Weslaco.

100 individual fruits was determined by displacement (1). Diameter was measured with a Vernier caliper and weight with a Sartorius Model E direct reading balance.

A ph relating weight to fruit diameter for each month was constructe m the data on the picked fruit sample. From this graph the weight the tagged fruit was obtained. At the end of the season the total n er of fruit from each tree was counted. The total weight of fruit p ee at each sampling date was calculated using the equation:

$$\text{Total wt.} = \frac{\text{wt. of tagged fruit} \times \text{total no. of fruit}}{\text{no. of tagged fruit}}$$

Volume calculations using either fruit diameter or diameter and height were compared with the individual fruit volume determinations. The formulation of an equation using volume instead of weight proved of no advantage in estimating the weight of the fruit on the tree. This result is supported by the constancy of the relationship between fruit height and diameter throughout the season. Similar findings were reported by other workers dealing with this problem (14, 15).

The determinations required by state regulations for testing citrus maturity were made on each sampling date to evaluate fruit quality. A sub-sample of 10-12 of the picked fruit was used for these tests.

The statistical techniques used were primarily those for comparing means of two populations (11).

RESULTS AND DISCUSSION

Increase in Weight of Fruit

The total weight of the fruit on the trees increased rather steadily from September to January in 1966 (Fig. 1A). In 1967 this increase was interrupted by a decline in weight gain in early December. From mid-January into early March in 1967 and late March in 1966 total weight remained nearly static or even decreased slightly. A rapid increase in weight occurred during late March and early April in 1967. The average weekly increase in fruit weight from September through December was approximately 3.3% in 1965 and 4.0% in 1966 (Fig 1B). From January through April the weekly weight increase averaged only 1.3% and 2.0% for 1966 and 1967, respectively. The differences between the two years were not statistically significant.

The periods in the winter where fruit failed to gain weight were closely associated with low temperatures (16). A reduced rate of fruit growth during January and February has been observed with grapefruit in Florida (3) and Arizona (5). In 1965-66 temperatures in the low 30's were not recorded until January 15th. Following this, such temperatures were experienced at almost weekly intervals until February 5th. Following two weeks of relatively warm weather, low temperatures again occurred in late February and early March. In contrast,

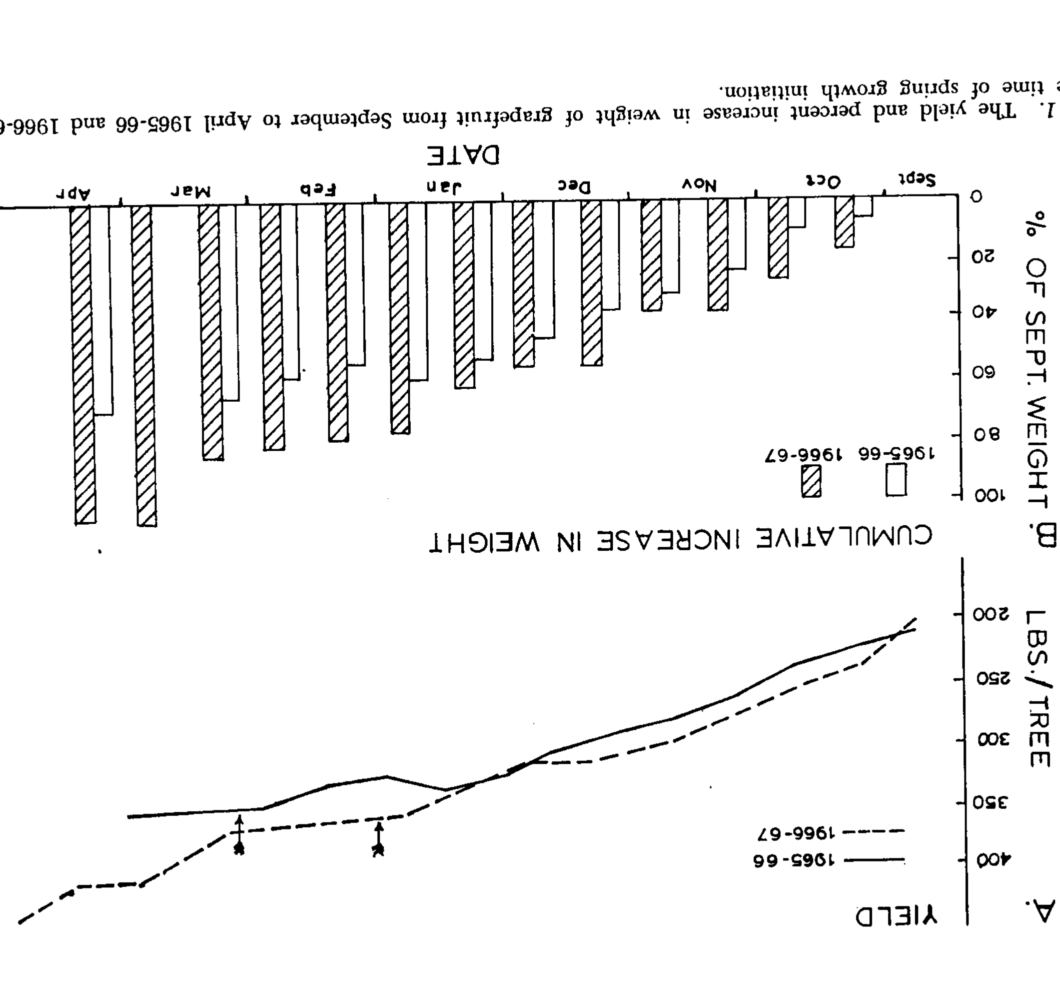

Figure 1. The yield and percent increase in weight of grapefruit from September to April 1965-66 and 1966-67. Arrows in 1A indicate time of spring growth initiation.

the 1966-67 season was characterized by freezing temperatures in early December, January and February. The periods of low temperatures are reflected in the growth curves for both seasons. In California and Arizona, a reduction in growth of both oranges and grapefruit was associated with cold weather (2, 6). Valencia oranges stopped growing at temperatures of 30-33 F and actually shrank at temperatures below 28 F.

Since fruit is sold by the ton, the decrease in weight gain during cold periods is of significance to grower and buyer alike. There very probably are other factors involved in reduced fruit growth during this period. Moisture stress has been shown to slow fruit growth during the summer months, but hardly would have been a causal agent in the wet winter and spring of 1965-66 (12). The interaction of low temperatures with carbohydrate supply may be involved. In Fig. 1A the initiation of spring shoot growth is indicated with an arrow. During the following 2 or 3 weeks, fruit weight remained nearly static for both seasons. Shoot growth and blossoming, which were occurring in these periods, have high energy requirements and are usually accompanied by a large reduction in total leaf carbohydrates (8). If low temperature did not permit replenishment, carbohydrate supply may have been limiting and either the current or following year's crop adversely affected (2, 8, 9).

Distribution of Fruit by Size Class Throughout the Season

The percent change of grapefruit in the standard size classes from September through April is shown in Table 1. At any sampling date there was a greater percentage of larger fruit in 1966-67 than in the preceding season. While this data is based on measured fruit, the same trend was evidenced in the picked fruit. For 1966-67 the range in size distribution was greater than for 1965-66.

In both seasons between October 15 and November 15 fruit of size 96, or larger, accounted for 50 percent or more of the total weight. By late December, half the total fruit weight was size 80 or larger, and by late January fruit of size 70 or larger.

A "rule of thumb" states that Valley grapefruit will increase one size from November to February (13). These data indicate an increase in one commercial size class occurred every 5 to 7 weeks except for the January-February period.

Changes in Fruit Weight within the Same Size Class

Fruit of a given size class increased in weight throughout the season due to both an increase in the number of larger fruit within a size class and to an actual increase in weight of fruit of the same diameter.

Size 96 grapefruit ranges from 9.5 to 10.1 cm in diameter and size 64 ranges from 10.9 to 11.4 cm. As the season progressed the number of fruit in the upper halves of these size classes gradually increased (Fig. 2). This shift tended to increase the average fruit weight within

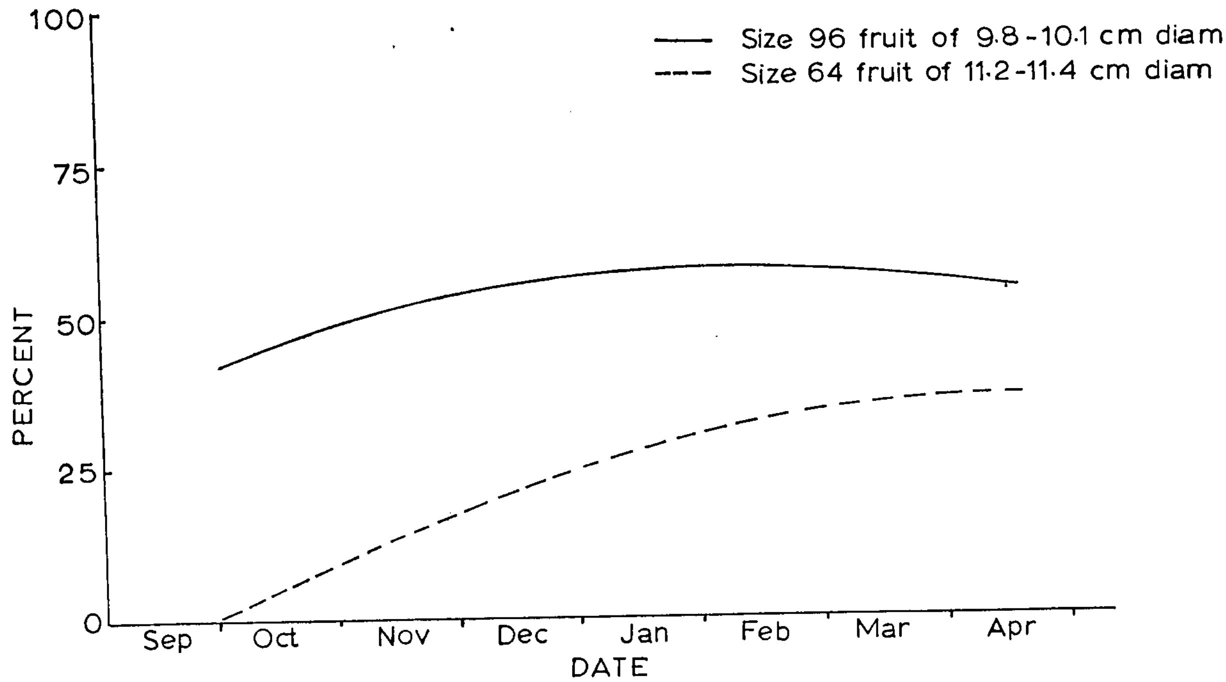

Figure 2. The change in percent of grapefruit in the upper half of the 96 and 64 size classes.

Table 1. Distribution (% of total weight) of grapefruit by size class for period, September-April, 1965-66 and 1966-67.

		SIZE CLASS								
DATE	*YEAR*	*Less than 126*	*126*	*96*	*80*	*70*	*64*	*54*	*46*	*Greater than 36*
Sept. 16-30	1965-66	51%	25%	24%						
	1966-67	52	26	10	12%					
Oct. 1-15	65-66	32	36	32						
	66-67	35	21	25	4	15%				
Oct. 16-31	65-66	28	31	37	4					
	66-67	19	32	21	8	11	9%			
Nov. 1-15	65-66	12	24	46	14	4				
	66-67	13	31	23	10	11	12			
Nov. 16-30	65-66	9	19	38	16	14	4			
	66-67	14	32	15	10	8	15	6%		
Dec. 1-15	65-66	5	19	44	14	10	8			
	66-67	7	26	22	7	10	19	9		
Dec. 16-31	65-66	5	14	30	16	20	15			
	66-67	7	22	21	5	18	14	13		
Jan. 1-15	65-66	3	9	25	22	25	12	4		
	66-67	8	18	19	4	16	18	14	3%	
Jan. 16-31	65-66	0	6	24	12	36	22			
	66-67	4	12	28	4	10	18	14	10	
Feb. 1-15	65-66	1	7	25	19	28	20			
	66-67	1	13	28	5	12	16	15	10	
Feb. 16-28	65-66	2	5	28	13	25	27			
	66-67	2	10	30	7	10	16	15	10	
Mar. 1-15	65-66	2	2	28	13	28	27			
	66-67	3	10	27	5	7	22	13	8	5%
Mar. 16-31	65-66	—	—	—	—	—	—	—	—	—
	66-67	0	5	20	10	13	18	15	3	16
Apr. 1-15	65-66	0	6	19	7	32	24	9	3	
	66-67	1	5	18	15	10	24	14	4	9

a size class. A similar shift occurred within all size classes but was more pronounced in classes having a greater range in actual fruit size.

In Table 2 are the average weights of fruit of 9.0, 10.0, 10.5, and 11.0 cm diameter. Because the two seasons exhibited identical trends, their data were averaged. The mean weight of fruit in each diameter class steadily increased to give an overall seasonal increase of about 17.1%.

This increase in weight cannot be explained by the data compiled in this study. The near constant ratio of fruit height to diameter argues against an increase in volume due to change in fruit shape, though this could occur even with height/diameter remaining constant. The fruit sample used for quality analysis revealed no change in density of the fruit throughout the season. Since this was a sample of random sizes it may not accurately represent fruit of the same size. The percent juice in the fruit increases by 5-7% from September to April. This must involve a change in water distribution rather than content. At a constant volume an increase in water content would also increase fruit density. The answer to this phenomenon would undoubtedly be revealed by more detailed study of volume-weight relationships and internal changes of the fruit.

Losses from Fruit Droppage

Fruit droppage throughout the season was estimated from the number of tagged fruit which fell from one date of measurement to the next. The figures in Table 3 may be slightly high since handling the fruit when measuring it may have increased droppage. Even if this is true, the data for the two years should be comparable.

Both the pattern and amount of droppage varied considerably between the two seasons. There did not appear to be any relationship between fruit size and dropping, but a larger sample is needed before this can be precisely determined.

Comparison of Fig. 1 and Table 3 indicates much of the gain in fruit weight is offset by losses from dropping. By April fruit drop had reduced yields by 3-4 T an acre in 1965-66 and 2-3 T an acre in 1966-67. Climatic factors no doubt play a leading role in this loss. In California fruit droppage has been considerably reduced by application

Table 2. Average weight of grapefruit of the same diameter at successive harvest dates.

	Fruit Diameter (±0.1 cm)			
Harvest Date	*9.0*	*10.0*	*10.5*	*11.0*
October	303 g	378 g	438 g	482 g
December	318	414	452	519
February	323	426	488	562
April	353	444	510	570

Table 3. Grapefruit droppage (percent of total fruit/tree) for the period, September-April, 1965-66 and 1966-67.

	DATE							
Year	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*
1965-66	0	3	6	12	19	21	26	29
1966-67	0	1	2	3	4	9	15	20

Table 4. Percent of grapefruit Size 80 or larger on partially picked and unpicked trees, September-April, 1965-66 and 1966-67[1].

		MONTH							
Year	*Tree Status*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*
1965-66	Unpicked	0	3	27	43	59	60	60	68
	Picked	5	3	32	30	62	52	61	62
1966-67	Unpicked	8	19	40	39	46	49	66	66
	Picked	0	6	31	37	62	58	83	85

[1] Ten fruit (1965-66) and 12 fruit (1966-67) were removed from picked trees every two weeks from September 15 through April 15.

of growth regulator sprays after the fruit has colored (4). This practice has yet to be evaluated in Texas.

The Effect of Partial Picking on the Growth of the Fruit Remaining on the Tree

An estimate of how the growth of fruit left on the tree is affected by early harvesting of part of the crop was obtained by comparing size distribution of the tagged fruit to the picked fruit at each sampling date. Table 4 shows the percent of size 80 or larger fruit on the picked and tagged trees from September through April. Reducing the number of fruit on the tree did not appear to increase the size of the unpicked fruit in 1965-66. In the latter half of 1966-67, however, early picking seemed to increase the number of larger size fruit. Studies on the effects of time of harvest on Valencia orange yields and size have not covered the effect of partial picking on the sizing of the remaining fruit of the current crop (7, 9). While early harvesting of large size grapefruit is common in the Valley, this practice is not strictly comparable to the method used in this experiment. Picking all size 96 or larger fruit in mid-October would remove 20-30% of the fruit (Table 1). By January 1st about 21% of the total number of fruit had been removed from the "picked" test trees, but the removal occurred over a four month period. The possibility of a causal relationship still exists, and the question is of sufficient interest to merit further study.

Yield variation in citrus is such that a considerable number of replications are required to ascertain the effects of any particular practice or treatment on fruit production (10). While there are no real treatment comparisons in most of the results reported above, the trends indicated would undoubtedly be reinforced or modified by data from additional trees and years.

CONCLUSIONS

The increase in fruit weight, changes in the amount of fruit in each size class, effects of early picking and the extent of fruit droppage will influence the marketable yield of grapefruit. As this affects their dollar returns both grower and buyer should be aware of these factors. With the reinforcement of data from additional seasons, the trends reported here may be of use in determining the most profitable time and method of harvesting.

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Cold Tolerance of Several Citrus Varieties and Strains on Sour Orange Rootstock During a Freeze in December 1966 at Crystal City, Texas

NORMAN P. MAXWELL[1]

INTRODUCTION

The Texas Agricultural Experiment Station and the United States Department of Agriculture, Crops Research Branch have been cooperating in testing under Texas climatic conditions, citrus crosses made by the USDA in Florida and California. The objective of this work is to develop tangerines and other citrus strains that will have cold hardiness and high quality fruit.

The Winter Garden area of Texas is noted for its ability to produce highly colored oranges, tangerines and tangelos for the Christmas market. Part of the reason for the excellent peel color is due to cool night temperatures in the fall and winter months. Night temperatures also have an effect on tree dormancy (1). Temperatures in the 40's and 30's will cause citrus trees to go dormant and thus increase their cold hardiness (2).

The Rio Grande Plains Research and Demonstration Station at Crystal City, Texas was selected as a location to test several citrus varieties and strains for their general adaptability to the Winter Garden area and particularly to their cold tolerance under freezing conditions.

MATERIALS AND METHODS

Five varieties and strains of mandarins and one early orange variety on sour orange roostock were planted in an adaptability test plot on the Rio Grande Plains Research and Demonstration Station at Crystal City, Texas in March, 1966.

Solid rows of each variety were planted with a pollinator row of Marrs early orange every sixth row. The planting was made on a contour bordered hillside having excellent air drainage. The soil was a sandy loam type. The trees were irrigated and banked with soil for cold protection in late November.

A freeze occurred on the nights of December 11, 12, 13 and 14, 1966. Table 1 gives the temperatures recorded from 10 p.m. to 8 a.m.

1 Associate Horticulturist, Texas Agricultural Experiment Station, Weslaco.

Table 1. Temperatures recorded at Rio Grande Plains Research and Demonstration Station during freeze of Dec. 11-14, 1966.

	Degrees Farenheit										
	10:00 P.M.	*11:00 P.M.*	*12:00 M.*	*1:00 A.M.*	*2:00 A.M.*	*3:00 A.M.*	*4:00 A.M.*	*5:00 A.M.*	*6:00 A.M.*	*7:00 A.M.*	*8:00 A.M.*
Dec. 11, 1966	36	34	32	30	28	27	26	26	25	25	25
Dec. 12, 1966	32	30	28	27	26	25	24	23	24	23	24
Dec. 13, 1966	40	36	32	30	28	28	28	26	25	23	23
Dec. 14, 1966	40	39	38	34	32	28	28	28	27	26	26

the next morning. The nights of December 12 and 13, when the lowest temperatures occurred, were still and clear with a greater loss of heat by sky radiation.

A cold damage reading was made on each tree in April 1967. The reading was delayed until April so that a full determination could be made of the amount of freeze damage. A scale of numbers from 1 to 5 was used in determining the freeze damage. Number 1 was partial defoliation, number 2 was defoliation with no wood damage, number 3 was defoliation with small twigs killed, number 4 was defoliation with twigs killed to one half inch wood and number 5 was killing of the top back to the soil bank.

RESULTS

Data were recorded on the degree of cold damage to each tree of all the varieties in the test in April 1967. Table 2 gives this data and Table 3 presents a percentage of damage by degrees based on Table 2 results.

The variety showing the most hardiness was Satsuma with fifty four percent of the trees in number 2 category and thirty-five and six tenths percent in number 3 category. The next most-hardy variety was Fairchild tangerine which had a total percentage of number 2 and 3 categories of about ninety percent. Fairchild showed slightly less hardiness than Satsuma because a greater number of the plants fell into number 3 category than into number 2. The other 3 tangerine varieties and strains, Nova, C53-4-7, and Bowers, showed less hardiness than Satsuma or Fairchild but were about the same hardiness in relation to one another. All of the mandarins were more cold hardy than Marrs early orange.

The amount of freeze damage on all of the varieties and strains was considerably less than would probably have occurred on similar aged trees in the Lower Rio Grande Valley. Table 4 gives the maximum, minimum and mean temperatures recorded at the Rio Grande Plains Research and Demonstration Station for the two weeks just previous to the freeze. The minimum temperatures are not as low as they generally are later in December and January but they are low enough to slow down tree growth and cause dormancy induction (2). Table 4 also gives maximum, minimum and mean temperatures recorded at Weslaco for two weeks previous to the freeze. A comparison of the minimum temperatures between Crystal City and Weslaco records shows that practically all minimum temperatures were several degrees lower at Crystal City than at Weslaco.

CONCLUSIONS

The Fairchild tangerine, an early maturing high quality variety, exhibited very good cold hardiness for nine-month-old orchard planted trees. Fairchild was very close to Satsuma in hardiness and has higher quality fruit than Satsuma maturing in the same season. Under the con-

ditions of the December 11-14, 1966 freeze, Fairchild exhibited more cold hardiness than the three other tangerine strains or Marrs early orange.

All of the varieties and strains in the test exhibited more tolerance to cold in the Winter Garden area than equal aged trees would have been expected to in the Lower Rio Grande Valley. A set of standards of how much cold a citrus variety will withstand will probably have to

Table 2. Number and variety of trees evaluated and degree of damage during the freeze of Dec. 11-14, 1966, at the Rio Grande Plains Research and Demonstration Station.

	Degree of Damage					No. of
	1	2	3	4	5	trees
Variety		*Percent of trees damaged*				*Evaluated*
Marrs orange	0	4	47	23	26	100
Fairchild tangerine	0	11	28	2	1	42
Nova tangerine	0	22	31	7	14	74
C53-4-7 tangerine	0	13	47	12	14	86
Bowers tangerine	0	7	31	10	12	60
Satsuma mandarin	0	47	31	5	4	87

1 Partial defoliation
2 Defoliation, no wood damage
3 Defoliation, small twigs killed
4 Defoliation, twigs killed to one half inch wood
5 Tree killed to soil bank

Table 3. Percent of trees damaged and degree of damage during the freeze of Dec. 11-14, 1966, at the Rio Grande Plans Research and Demonstration Station.

	Degree of Damage					No. of
	1	2	3	4	5	trees
Variety		*Number of trees damaged*				*Evaluated*
Marrs orange	0	4	47.0	23.0	26.0	100
Fairchild tangerine	0	23.8	66.7	4.8	2.4	42
Nova tangerine	0	29.7	41.9	9.5	18.9	74
C53-4-7 tangerine	0	15.1	54.7	14.0	16.3	86
Bowers tangerine	0	11.7	51.7	16.7	20.0	60
Satsuma mandarin	0	54.0	35.6	5.7	4.6	87

1 Partial defoliation
2 Defoliation, no wood damage
3 Defoliation, small twigs killed
4 Defoliation, twigs killed to one half inch wood
5 Tree killed to soil bank

Table 4. Temperatures recorded for two weeks previous to the freeze of December 11-14, 1966 at the Rio Grande Plains Research and Demonstration Station at Crystal City, Texas and at the Texas Agricultural Experiment Station No. 15, Weslaco, Texas.

	November				*December*									
	27	*28*	*29*	*30*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Crystal City, Texas (*Degrees Farenheit*)														
Maximum	72.0	67.0	71.0	73.0	73.0	80.0	66.0	76.0	79.0	83.0	87.0	86.0	75.0	55.0
Minimum	51.0	35.0	31.0	39.0	48.0	47.0	57.0	51.0	54.0	58.0	56.0	61.0	43.0	38.0
Mean	61.5	51.0	51.0	56.0	60.5	63.5	61.5	63.5	66.5	70.5	70.5	73.5	59.0	46.5
Weslaco, Texas														
Maximum	93.0	65.0	72.0	80.0	79.0	81.0	81.0	82.0	82.0	83.0	84.0	85.0	83.0	75.0
Minimum	60.0	39.0	34.0	44.0	50.0	59.0	56.0	59.0	61.0	67.0	71.0	71.0	63.0	45.0
Mean	66.5	52.0	53.0	62.0	64.5	70.0	68.5	70.5	71.5	75.0	77.5	78.0	73.0	60.0

be worked out both in the Lower Rio Grande Valley and in the Winter Garden region.

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Tests of Insulating Materials for Citrus Tree Trunk Freeze Protection Using Controlled Freezing Conditions[1]

Roger H. Young, John E. Fucik, and Richard A. Hensz[2]

Abstract. Two-year-old budded citrus trees growing in the field and in 5-gallon crocks were subjected to severe freezing conditions to test the effectiveness of several materials for tree trunk freeze protection. Although tree trunks banked with soil were the warmest, 4-inch wraps of fiberglass and polyurethane were satisfactory in preventing freeze injury under the test conditions. "Air-flow" Tree Protector was not as effective as polyurethane in pot tests.

INTRODUCTION

Protecting the trunks of young citrus trees from freeze injury with soil banks has been a standard practice for years in the Rio Grande Valley of Texas. In 1956, P. W. Rohrbaugh introduced the idea of using rock wool, an inert material, for a permanent tree wrap. These wraps proved effective for trunk protection in the 1962 freeze (2). More recently, other inert materials have been studied for potential use as tree trunk wraps for freeze protection (1). This report summarizes results from freeze tests designed to compare the standard soil bank with wraps made of several types of inert material.

MATERIALS AND METHODS

Plant materials. Trees growing in the field were 2-year-old Redblush grapefruit on sour orange rootstock planted 5 feet apart in a 16-tree block. Trees used in a pot test were 2-year-old Valencia oranges on sour orange rootstock planted in 5-gallon crocks.

Trunk protection materials. Materials used in the tests were: a) soil; b) Owens-Corning fiberglass building insulation, 2, 3, 4, and 5 inches thick; 3) polyurethane foam, 1, 3, and 4 inches thick; and d) "Air-flow" Tree Protector, ¾ inch thick. All trunk protection materials were approximately 18 inches high. The characteristics of these materials have been previously described (1).

Temperature measurements. Air (tree height) and trunk temperatures at the bud union (6 inches) and 12 inches high were measured

[1] The work was a cooperative project of the Agricultural Research Service, U. S. Department of Agriculture, the Texas Agricultural Experiment Station, Weslaco, Texas, and Rio Farms, Inc., Monte Alto, Texas.

[2] Plant Physiologist, Crops Research Division, U. S. Department of Agriculture; Assist. Prof. of Agriculture and Assoc. Prof. of Agriculture, Director, Texas College of Arts & Industries, Citrus Center, Weslaco, Texas.

every hour with copper-constantan thermocouples and a multipoint recorder. Thermocouples were taped to the trunk for convenience. Measurements were made on 2 trees in each treatment and results are expressed as averages.

Freeze tests. The freeze chamber used for the tests was previously described (3) and modified by the addition of more refrigeration. The February 24 and March 3, 1965, tests on Redblush grapefruit trees were started at 6:00 P.M. The air temperature was lowered rapidly to 32 F., the coils defrosted, and the air temperature again lowered continuously until minimums of 20 and 18 were reached respectively. The tests were then terminated.

In March, 1967, a more severe freeze test was made with a second set of 16 Redblush grapefruit trees. At 3:00 P.M., March 8, the freeze chamber was started and the temperature lowered to 32 F., by 6:00 P.M. The temperature was then lowered 2 degrees per hour until 6:00 A.M. when a minimum of 23 was reached. The coils were defrosted during which time the air temperature rose to 31. The air temperature was then lowered to 21 and controlled there from 1:00 to 7:00 P.M., March 9, when a second defrost was initiated. Following the defrost the air temperature was lowered from 25.5 to 15 and the test was terminated at 5:00 A.M., March 10.

A fourth test used 2-year-old Valencia oranges in 5-gallon crocks. The trees were placed in a freeze chamber at 35 F. for 35 hours following which the temperature was lowered to 15 at a rate of 2 degrees per hour.

Freeze injury. Trees were rated for freeze injury 4 to 6 weeks after the freeze test which consisted of observations on leaf and wood injury.

RESULTS AND DISCUSSION

Field tests. Tests made February 24 and March 3, 1965, were similar (Tables 1 and 2). The March 3 test was 4 hours longer at temperatures 21 F. or lower. The trees were in an active state of growth; therefore all tops were killed to the bank or wrap tops. Those unbanked were killed below the bud union. Trunk temperatures in the banks or wraps never went below 28.5 while those of unbanked trees reached as low as 20.2 in the March 3 test. The most effective bank was soil followed by decreasing thicknesses of fiberglass. Trunk temperatures 6 inches high were warmer than 12 inches. Under the conditions of this test, 2 inches of fiberglass gave adequate protection.

A more severe freeze test was made March 8 to 10, 1967. Soil banks were compared to 4-inch-thick wraps of fiberglass and polyurethane foam (Table 3). Air temperatures were 32 F. or lower for 35 hours and 22 or lower for 16 hours. The minimum air temperature reached was 15 (Table 2). This test was considered as severe as the 1951 and 1962 freeze in Texas. Trunk temperatures of unbanked trees reached minimums between 14.6 and 15.1 and were killed to the ground. Lowest

Table 1. Trunk temperatures and freeze injury on 2-year-old Redblush grapefruit trees on sour orange rootstock banked with soil and fiberglass and exposed to subfreezing temperatures in a freeze chamber in the field.

Bank type	*No. of trees*	*Feb. 24, 1965 Final trunk temperature (°F)*		*March 3, 1965 Final trunk temperature (°F)*		*Tree injury*
		6 inches	*12 inches*	*6 inches*	*12 inches*	
No bank	3	25.2	24.7	20.7	20.2	Dead
Soil bank	3	47.3	36.8	44.5	34.2	Alive to bank top
Fiberglass bank:						
2 inches	2	34.7	29.2	31.6	28.5	Alive to wrap top
3 inches	3	35.2	30.5	31.7	28.7	Alive to wrap top
4 inches	3	37.8	31.0	33.9	28.7	Alive to wrap top
5 inches	2	39.2	34.2	35.8	31.8	Alive to wrap top

Table 2. Number of hours air temperature in freeze chamber was below various minimums during bank test.

Minimum temperature	*Hours air temperature below indicated minimums — Field tests: Feb. 24, 1965 (hrs.)*	*March 3, 1965 (hrs.)*	*March 8 to 10, 1967 (hrs.)*	*Pot test (hrs.)*
35	—	—	—	46½
32	8¾	12½	35	8½
30	8¾	12½	31	7½
28	8	11½	29	6½
26	7¾	11½	24	5½
24	6¾	10½	19½	4½
22	5½	6½	16	3½
21	½	6	15	3
20	0	1	4	2½
19	0	½	3½	2
18	0	0	3	1½
17	0	0	2	1
16	0	0	1½	½
15	0	0	1	½
14	0	0	0	0

Table 3. Trunk temperatures and freeze injury on 2-year-old Redblush grapefruit trees on sour orange rootstock banked with soil, fiberglass, and polyurethane and exposed to subfreezing temperatures in a freeze chamber in the field.

Bank type	*No. of trees*	*March 8 to 10, 1967 Final trunk temperature (°F) 6 inches*	*12 inches*	*Tree injury*
No bank	4	14.6	15.1	Dead
Soil bank	4	35.6	29.0	Alive to bank top
Fiberglass bank	4	28.7	25.1	Alive to wrap top
Polyurethane foam bank	4	28.8	27.7	Alive to wrap top

trunk temperatures reached in any of the banks was 25.1 at the 12 inch high point in the fiberglass wrap while the warmest temperatures were recorded in the soil banks. Both fiberglass and polyurethane provided adequate protection to the trunks.

In a pot test, 2 thicknesses (1 and 3 inches) of polyurethane were compared to a ¾-inch bank of corrugated cardboard, "Air-flow" Tree Protector (Table 4). Air temperature was controlled at 35 F. for 35 hours followed by a drop of 2 degrees per hour to a minimum of 15.

Table 4. Trunk temperatures and freeze injury on Valencia orange trees on sour orange rootstock in 5-gallon crocks wrapped with polyurethane and corrugated cardboard exposed to subfreezing temperatures in a freeze chamber.

Bank type	*No. of trees*	*Final trunk temperatures (°F)* 6 inches	12 inches	*Tree injury*
No wrap	4	14.7	16.8	Dead
Polyurethane:				
3 inches	4	25.6	25.6	Alive 6 inches above bud union
1 inch	4	24.2	23.3	Alive 1 inch above bud union
Corrugated cardboard	4	22.0	16.6	Alive 1 inch above bud union

Trunk temperatures of unbanked trees reached minimums of 14.7 to 16.8 and were killed to the ground. A 3-inch bank of polyurethane provided trunk protection 6 inches above the bud union while 1-inch of polyurethane barely protected the bud union. The corrugated cardboard provided slightly less protection than the 1-inch polyurethane bank.

These tests were designed to determine the effectiveness of various trunk protecting materials over wide ranges in severity of freeze conditions. The tests on February 24 and March 3, 1965, were 1-day tests with minimums of 20 and 18 F. The tests on March 8 to 10, 1967, and with pots were very severe in that temperatures near or below 32 were maintained for 2 days with a minimum of 15 being reached on the last day. Under the most severe freezing condition, soil banks maintained the warmest trunk temperatures but 4 inches of fiberglass and polyurethane provided enough insulation to maintain trunk temperatures above the injury point. While the corrugated cardboard wrap was tested only with potted trees, its value for trunk protection under very severe freeze conditions is questionable. The effectiveness of 4-inch wraps of fiberglass and polyurethane is in agreement with the findings of Fucik and Hensz (1). Further tests are required, however, to determine if lesser thicknesses of fiberglass and polyurethane would be practical for trunk protection during very severe freezing conditions.

This is a report on the relative effectiveness of various insulating materials for tree trunk protection during severe freezing conditions. Mention of brand names does not imply that the items have or have not been recommended.

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Freeze Injury to 3-Year-Old Citrus Hybrids and Varieties Following Exposure to Controlled Freezing Conditions[1]

ROGER H. YOUNG and ASCENSION PEYNADO[2]

Abstract. Sixty-nine 3-year-old citrus hybrids and varieties were frozen during the 1966-67 winter. Those showing the most hardiness were Orlando, Lee, Page, Osceola, Fortune, Dancy, Murcott, Fremont, Kara, Redblush, Valencia, and several other numbered selections. Selections from crosses with Clementine, Wilking, and Temple were generally hardier than those from crosses with pummelo, grapefruit, or Rangpur lime as the female parent. Tree dormancy was a factor in the injury sustained during the tests.

INTRODUCTION

Many new citrus hybrids from the USDA breeding program are tested to determine their general adaptation to South Texas conditions (2, 3, 4). One desirable characteristic of a new hybrid is winter cold hardiness. This report summarizes cold hardiness evaluation tests during the 1966-67 winter on 69 citrus hybrids and varieties.

MATERIALS AND METHODS

Plant materials. Each of 69 hybrids or scion varieties were budded on 4 seedlings and the 276 trees were set in the field on February 13, 1964. Forty-one types were budded on sour orange rootstocks and 28 were budded on Carrizo and 7-20-12 citrange rootstocks in approximately equal numbers. They were planted on 5-foot centers so that a portable freezer box (5) could be placed over several trees. The scion varieties budded on sour orange seedlings were grouped into blocks of 9, 12, or 16 by random choice, but no 2 trees in one block were alike. The scions budded on citrange seedlings were grouped separately in the same manner in blocks of 12 or 16.

Weed control in the close-planted blocks was accomplished by a Karmex application in the spring and spot-oiling throughout the growing season. Fertilizer application was standard except that zinc was applied as a spray in the spring to control zinc deficiency problems in the tangerine types. Water and insect control applications were made when needed.

[1] The work was a cooperative project of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and the Texas Agricultural Experiment Station, Weslaco, and Rio Farms, Inc., Monte Alto, Texas.

[2] Plant Physiologist and Chemist, respectively, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas.

Freeze test and injury ratings. A portable field freezer was erected around a block of trees during the day, and the freeze test was run during the evening. Air temperature in the chamber was lowered to 20°F between 5 and 8 P.M. and maintained there for 4 hours; then the test was terminated. Humidity during the test ranged between 40 and 60%.

All trees on sour orange rootstock were frozen between January 3 and 21, 1967, and those on citrange rootstock were frozen between January 24 and February 5, 1967. Bark-peeling index ratings were made on twigs and trunks of all trees the day of the freeze test as a measure of the dormancy status of the trees.

Freeze injury ratings were made between March 1 and 15, 1967, after injury had fully developed and buds had begun growing. This consisted of estimating percent defoliation and dead wood on terminals, ¼-, ½-, ¾-, 1-, and 2-inch wood on each tree. From these data each tree was given a freeze injury rating which estimated the size of wood (inches) to which half the branches were dead. Observations were also made on bark splitting.

Freeze injury ratings of scions on the 2 citrange rootstocks were averaged since differences between them were small.

RESULTS AND DISCUSSION

Average weekly maximum temperatures, 2 weeks prior to and during the tests on scions budded on sour orange rootstocks, ranged from 56° to 71°F; and average weekly minimum temperatures ranged from 44° to 58° (Table 1). Twig and trunk bark-peeling ratings were very similar on most scions but some varied greatly (Tables 2 and 3). Bark-peeling index ranged from 0.8 to 1.5 in the twigs and 0.8 to 3.0 in the trunks. Tree injury was light on many of the scions, but some were se-

Table 1. Average weekly maximum and minimum temperatures 2 weeks prior to and during freezing tests.

Date 1966-67	*Air (°F)*	
	Maximum	*Minimum*
December 13-20	76	42
December 21-27	70	51
December 28-January 3	68	51
January 4-10	56	44
January 11-17	68	50
January 18-24	71	58
January 25-31	80	56
February 1-5	71	61

Table 2. Bark-peeling status before freezing and freeze injury to 3-year-old citrus hybrids and varieties on sour orange rootstock following exposure to 20°F for 4 hours.

Parents of hybrid or type	*No. or name of selection*	*Bark-peeling index*[1] *twig*	*Bark-peeling index*[1] *trunk*	*Tree injury defoliation (%)*	*Tree injury wood injury (inches)*
'Duncan' x 'Dancy'	'Orlando'	1.0	1.7	90	trace
'Clementine' x 'Mott'	'Lee'	1.2	1.2	100	0.05
'Clementine' x 'Dancy'	53-4-59	1.0	1.8	100	0.05
OPS 'Citradia'	53-30-1	0.8	2.0	100	0.05
'Valencia'	—	1.0	2.0	100	0.06
'Wilking' x 'Dweet'	S2B-52-3	1.0	1.5	100	0.06
'Clementine' x 'Kinnow'	54-35-5	1.0	1.8	100	0.07
'Minneola' x 'Clementine'	'Page'	1.0	2.5	88	0.07
'Redblush'	—	1.0	3.0	100	0.07
'Wilking' x 'Mency'	S2B-53-10	1.0	2.0	100	0.09
'Osceola'	—	1.0	1.5	100	0.09
'Clementine' x 'Dancy'	'Fortune'	1.0	2.0	100	0.09
'Dancy'	—	1.0	1.0	100	0.10
'Clementine' x 'Frua'	S2C-61-2	1.0	1.0	100	0.10
'Tankan' mandarin	—	1.0	1.8	100	0.10
'Clementine' x 'Dancy'	53-4-68	1.0	2.2	100	0.10
'Clementine' x 'Orlando'	6-5-15	1.0	1.0	100	0.11
sweet orange x tangerine?	'Murcott'	1.0	1.7	100	0.11
Pummelo x 'Frua'	S2C-38-4	1.0	1.8	100	0.12
'Robertson' navel	—	1.0	2.0	100	0.12
'Clementine' x 'Wilking'	48-24-45	1.0	2.0	100	0.12

Table 2. Bark-peeling status before freezing and freeze injury to 3-year-old citrus hybrids and varieties on sour orange rootstock following exposure to 20°F for 4 hours. (continued):

Parents of hybrid or type	*No. or name of selection*	*Bark-peeling index*[1] *twig*	*Bark-peeling index*[1] *trunk*	*Tree injury defoliation (%)*	*Tree injury wood injury (inches)*
'Clementine' x 'Ponkan'	'Fremont'	1.0	2.0	100	0.12
'Clementine' x 'Orlando'	48-14-30	1.0	2.7	100	0.12
'Owari' x 'King'	'Kara'	1.0	2.7	100	0.12
Red pummelo x 'Foster'	52-60-1	1.0	2.0	100	0.13
'Temple' x 'Minneola'	52-27-22	1.0	2.5	100	0.13
'Wilking' x 'Dweet'	S2B-52-1	1.0	2.2	100	0.13
'King' x 'Temple'	52-84-35	1.0	0.8	100	0.13
'King' x 'Temple'	52-84-36	1.0	1.5	100	0.14
'Redblush' x 'Webber'	52-58-6	1.0	1.7	100	0.14
'Wilking' x 'Dweet'	S2B-69-9	1.0	1.0	100	0.19
'Temple' x 'Frua'	S2B-50-10	1.0	1.8	100	0.19
'Umatilla' x 'Honey'	52-76-9	1.2	1.0	100	0.20
'Wilking' x 'Dweet'	S2B-68-7	0.8	1.8	100	0.22
'Temple' x 'Frua'	S2B-50-11	1.0	2.5	100	0.23
'Laranjo Cravo'	—	1.0	1.3	100	0.23
'Clementine' x 'Orlando'	'Robinson'	1.0	2.7	100	0.24
'Messina' x 'Meyer'	52-105-9	1.5	3.0	100	0.25
'Clementine' x 'Orlando'	'Bower'	0.8	1.2	100	0.35
'Rosenberger' x 'Meyer'	52-104-7	1.5	2.2	100	0.75
'Messina' x 'Meyer'	52-105-16	1.5	3.0	100	0.75

[1] 0 = bark does not peel; 1 = bark barely peels; 2 = bark peels easily; 3 = bark peels easily and is moist.

Table 3. Grouping of citrus types from Table 2 into freeze-injury categories.

Freeze-injury category	No. of types	Bark-peeling index[1]		Tree injury	
		twig	trunk	defoliation (%)	wood injury (inches)
25% terminals dead	9	1.0	1.9	98	0.06
50% terminals dead	21	1.0	1.8	100	0.11
50% ¼-inch wood dead	8	1.1	1.9	100	0.22
50% ⅓-inch wood dead	1	0.8	1.2	100	0.35
50% ¾-inch wood dead	2	1.5	2.6	100	0.75

[1] See Table 2 for explanation.

verely injured. Nearly all trees were completely defoliated. Wood injury ranged from none to 50% killing of ¾-inch wood. No bark splitting was evident on any of the trees. On 30 of the 41 types tested in this group, 50% or less of the terminal wood was killed (Table 3). Three types had 50% killing of ⅓- to ¾-inch wood. Those showing considerable hardiness with 50% or less of the terminals killed were Orlando, Lee, Page, Osceola, Fortune, Dancy, Murcott, Fremont, Kara, Redblush, Valencia, Tankan mandarin, Robertson navel, and 17 numbered selections. Most of the types tested had tangerine parentage and would be expected to have hardiness. Robinson and Bower, however, did not have as much hardiness as the others. A selection from a Meyer lemon cross, 52-105-9, also exhibited some hardiness.

Average weekly maximum temperatures 2 weeks prior to and during the tests on scions budded on citrange rootstocks ranged from 56° to 80°F and average weekly minimums ranged from 44° to 61° (Table 1). Because of warmer days and nights preceding the tests, these trees exhibited less dormancy and hardiness (Tables 4 and 5). Bark-peeling index was similar on most scions and ranged from 1.2 to 1.9 in the twigs and 1.3 to 3.0 in the trunks. In the freezing tests, all trees were defoliated. Wood injury ranged from 50% killing of the terminals (0.12) to 50% killing of the ¾-inch wood. Severe bark splitting was apparent on trees of 54-58-1, 54-63-21, and 54-63-27. Most selections in this group were from crosses in which Clementine was the female parent. Thirteen of the 28 selections tested on citrange rootstock had 50% killing of the ¼-inch wood and 6 had 50% killing of the ¾-inch wood.

Sixty percent of the selections tested during the 1966-67 winter were from crosses in which Clementine, Temple, or Wilking was the

female parent. Most of these exhibited hardiness under the test conditions. Most selections from crosses with pummelo, grapefruit, or Rangpur lime as a female parent were less hardy. These results were in general agreement with observations by Furr, et al. (1).

Valencia orange and Redblush grapefruit exhibited considerable

Table 4. Bark-peeling ratings before freezing and freeze injury to 3-year-old citrus hybrids and varieties on citrange rootstock following exposure to 20°F for 4 hours.

Parents of hybrid or type	No. or name of selection	Bark-peeling index[1]		Tree injury	
		twig	trunk	defoliation (%)	wood injury (inches)
'Clementine' x 'Honey'	53-2-67	1.2	1.5	100	0.12
'Clementine' x 'Honey'	53-2-70	1.2	2.0	100	0.12
OPS 'Citradia'	53-30-1	1.4	1.5	100	0.12
'Clementine' x 'Silverhill Satsuma'	54-1-12	1.2	1.9	100	0.14
'Clementine' x 'Silverhill Satsuma'	54-1-5	1.4	2.0	100	0.15
'Clementine' x 'Honey'	53-2-66	1.2	1.9	100	0.15
'Clementine' x 'Hamlin'	53-1-15	1.2	2.0	100	0.15
'Clementine' x 'Hamlin'	53-1-16	1.2	1.5	100	0.19
'Clementine' x 'Honey'	53-2-28	1.2	2.2	100	0.19
'Clementine' x 'Dancy'	53-4-67	1.2	2.0	100	0.19
'Clementine' x 'Silverhill Satsuma'	54-1-4	1.2	1.5	100	0.19
'Clementine' x 'Silverhill Satsuma'	54-1-9	1.5	1.5	100	0.19
'Clementine' x 'Silverhill Satsuma'	54-1-14	1.5	1.9	100	0.19
'Clementine' x 'Wilking'	48-24-50	1.3	2.0	100	0.20

Table 4. Bark-peeling ratings before freezing and freeze injury to 3-year-old citrus hybrids and varieties on citrange rootstock following exposure to 20°F for 4 hours. (continued):

Parents of hybrid or type	No. or name of selection	Bark-peeling index[1] twig	Bark-peeling index[1] trunk	Tree injury defoliation (%)	Tree injury wood injury (inches)
'Clementine' x 'Wilking'	48-24-28	1.3	2.2	100	0.23
'Clementine' x 'Dancy'	53-4-78	1.2	1.9	100	0.23
'Clementine' x 'Wilking'	48-24-45	1.2	1.9	100	0.25
'Clementine' x 'Honey'	53-2-44	1.2	1.5	100	0.25
'Temple' x 'Red Shaddock'	48-17-3	1.6	2.5	100	0.27
'Clementine' x 'Honey'	53-2-73	1.2	2.5	100	0.27
'Clementine' x 'Honey'	53-2-71	1.4	1.9	100	0.37
'CES Red grapefruit'	—	1.2	2.3	100	0.37
'Kao Phuang' pummelo selfed	48-4-19	1.2	2.3	100	0.70
'Clementine' x 'Silverhill Satsuma'	54-1-13	1.5	2.5	100	0.75
'Shekwasha' x 'Rangpur'	54-58-1	1.9	3.0	100	0.75
'Rangpur' x 'Shekwasha'	54-63-21	1.9	2.5	100	0.75
'Rangpur' x 'Shekwasha'	54-63-27	1.5	3.0	100	0.75
'Temple' selfed	54-76-2	1.3	1.3	100	0.75

[1] See Table 2 for explanation.

hardiness, under the test conditions, as compared to Orlando tangelo, Dancy tangerine, and Lee, Page, and Fortune hybrids. This result probably stemmed from a response of the variety to a specific set of hardening conditions which coincided with our freeze tests. It is expected that under a greater range of hardening conditions, the tangerine and tangerine hybrids would show more hardiness potential than Valencia orange and Redblush grapefruit. A CES grapefruit selection from California, which exhibited hardiness characteristics similar to other grapefruit varieties in the 1962 Texas freeze (7, 8) was also tested. This selection, which was budded on citrange rootstocks (Table 4) had 50% killing of the ⅓-inch wood as compared to Redblush on sour orange rootstock which had only slight terminal injury. This difference in hardiness was mainly attributed to climate changes affecting hardiness since day and night temperatures prior to the freeze tests were warmer for the CES selection than for Redblush. Rootstock may have been a factor since in some instances citrange rootstocks did not induce as much hardiness as sour orange rootstocks (6, 9).

Table 5. Grouping of citrus types from Table 4 into freeze-injury categories.

Freeze category	No. of types	Bark-peeling index[1] twig	Bark-peeling index[1] trunk	Tree injury defoliation (%)	Tree injury wood injury (inches)
25% terminals dead	0	—	—	—	—
50% terminals dead	7	1.3	1.8	100	0.14
50% ¼-inch wood dead	13	1.3	1.9	100	0.22
50% ⅓-inch wood dead	2	1.3	2.1	100	0.37
50% ¾-inch wood dead	6	1.6	2.4	100	0.74

[1] See Table 2 for explanation.

This is a report on the relative hardiness of many citrus hybrids and varieties during the 1966-67 winter. The use of herbicides and specific fertilizer practices in these studies does not imply a recommendation.

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Marrs Orange as a Pollinator for Orlando Tangelo[1]

R. A. Hensz[2]

Abstract: The Marrs orange was found to be an effective pollinator for Orlando tangelo. In controlled pollinations 81% of the Orlando flowers pollinated with Marrs pollen set fruit, all of which were seedy. Only 6% of the self-pollinated Orlando flowers set fruit, all of which were seedless. Observations in a commercial planting of Marrs with Orlando showed the Orlando trees bore a heavy crop of seedy fruit.

INTRODUCTION

The Orlando tangelo is a hybrid of a seedy white grapefruit and Dancy tangerine (5). It is an excellent quality fruit, is usually harvested before Christmas, and generally commands a good market price.

The Orlando is often unfruitful when grown in solid plantings due to its inability to set seed following self-pollination and its lack of a strong parthenocarpic tendency (1, 2, 4). Under such conditions it may set light crops of relatively seedless fruit. Acceptable production cannot be expected unless suitable pollinator varieties are interplanted with the Orlando. When such pollinators are present and the bloom period of the 2 varieties overlap good crops may be produced. This fruit will usually be quite seedy.

In recent years interest has grown in Orlando tangelo plantings in Texas. Of the varieties reported to be suitable pollinators (2) only Dancy tangerine and Temple and Pineapple orange are grown commercially in this area. The purpose of the work reported here was to determine if the Marrs orange would be a satisfactory pollinator for the Orlando tangelo.

MATERIALS AND METHODS

Hand pollinations were made on Orlando tangelo flowers at Weslaco, Texas. Leafy bloom (3) was used with the flower on the apex emasculated and petals removed prior to pollination. Fifty Orlando flowers were cross-pollinated with Duncan pollen, 100 were cross-pollinated with Marrs pollen, and 100 were self-pollinated. Duncan was used for comparison because it is known to be an effective pollinator for the Orlando (2). No effort was made to guard the pollinated flowers inasmuch as polliniferous bees are not seen visiting depetaled flowers.

[1] Cooperative citrus research of Texas A & I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.
[2] Director, Texas A & I University Citrus Center, Weslaco.

In a commercial orchard the natural occurring fruit set on Orlandos planted with Marrs was observed.

RESULTS AND DISCUSSION

The percentage of hand-pollinated flowers that produced fruit and the relative seediness of the fruit is shown in Table 1. Marrs pollen was as effective as Duncan pollen in setting Orlando fruit. Compared to 81 and 76% fruit set of the cross-pollinated flowers only 6% of the self-pollinated set fruit.

Examination of the fruit showed all that were cross-pollinated were seedy, having more than 10 seeds per fruit (Table 1). In contrast the fruit from self-pollination were all seedless.

Field observations were made in a commercial orchard where alternating double rows of Orlando tangelo and Marrs orange occur in the planting. During the bloom period the Marrs flowered first but there was a 7-day overlap between the 2 varieties. Although in the previous year there was a similar overlap in the bloom period, it is not known whether this could be expected every year.

The Orlando trees in the commercial orchard produced a heavy crop of fruit. A random sampling of this fruit showed 90% to be seedy with more than 10 seeds per fruit, 8% were seedy but had less than 10 seeds per fruit, and 2% were seedless.

These observations reaffirm reports that in solid plantings where only self-pollination is likely to take place the Orlando is often commercially unfruitful but may be found to set a small amount of relatively seedless fruit (2, 4). On the other hand if sufficient and suitable pollinators are provided in Orlando plantings good crops may be produced but most of the fruit will be seedy.

CONCLUSIONS

The results of this study indicate that in commercial plantings Marrs orange would be a suitable pollinator for Orlando tangelo when there is an adequate overlap in the bloom period of the two varieties.

Table 1. Fruit-set and seediness of fruit following hand pollination of Orlando Tangelo.

Pollen source	*% Fruit Set*	*Seediness*[1]
Marrs	81	Seedy
Duncan	76	Seedy
Orlando	6	Seedless

[1] Seedy fruit had over 10 seeds per fruit. Seedless fruit had no seeds.

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VEGETABLE AND OTHER

Influence of Potassium Fertilizer on Yield and Chemical Composition of Cantaloupe Grown on a High Potassium Soil

BILLY W. HIPP and R. T. CORREA[1]

Abstract. Cantaloupes were grown on Willacy fine sandy loam soil with various rates of potassium fertilizer. There was no beneficial response from the applied K. High rates of K resulted in delayed maturity of the melons. There was very little influence on cation uptake by the plants with K fertilization.

Numerous reports unsubstantiated by experimental data have been made regarding the influence of added potassium (K) on cantaloupe and other crops growing on clay loam and fine sandy loam soils of the Lower Rio Grande Valley. Potassium is a necessary element for the growth of plants but many of the soils of the Valley are of the mixed montmorillonite-mica clay type that would not be expected to respond to K application (2). In general, these soils test very high in K; furthermore, it is in a form that is available to plants. Although fixation of K by clay minerals has been found to occur (5), it is not a serious problem where abundant available potassium is present. A field experiment was initiated at the Lower Rio Grande Valley Research and Extension Center in order to determine the influence of soil applied K fertilizer on yield, chemical composition and quality of cantaloupes where large amounts of available K were already present.

MATERIALS AND METHODS

The field experiment consisted of a randomized block design with 4 replications. The plots were 3 rows 45 feet long (row spacing was 76 inches). Yield and plant samples were obtained from the center row of each plot.

The soil used was Willacy fine sandy loam. The chemical properties of the soil are shown in Table 1. Potassium treatments were banded preplant at rates of 0, 20, 40, 60 and 200 pounds per acre of elemental K. The source of K was muriate of potash. A preplant application of 80 pounds per acre of phosphorus was banded in the soil on all plots. Cantaloupe (var. Perlita) was planted on March 2, 1966, and thinned to 14 inches between plants when a stand was established. The plants were sidedressed with 40 pounds per acre of N when the plants were 4 weeks old. Normal management practices for the area were used throughout the experiment.

[1] Assistant Professor and Assistant Horticulturist, Texas A&M University, Texas Agricultural Experiment Station, Lower Rio Grande Valley Research and Extension Center, Weslaco, Texas.

Leaf samples were taken for chemical analyses when plants were 56 and 80 days old. Young mature leaves were sampled and prepared for analyses by the procedure outlined by Chapman and Pratt (1). Cation determinations were made on the plant tissue with a Techtron Atomic Absorption Spectrophotometer. Harvest was started at the first sign of mature melons and every other day thereafter for 10 harvests. Melons were sized and weighed; Brix was evaluated at each harvest with a hand refractometer.

RESULTS AND DISCUSSION

Since the early market is of prime importance in cantaloupe marketing, the harvest data were broken into two harvest periods, the first 5 harvests and the second 5 harvests. Yields of the two harvest periods and total yield of melons are shown in Table 2. The data indicate that no beneficial response was obtained from the K application. Conversely, the K had a tendency to delay fruit maturity and vine growth especially at the rates above 40 pounds per acre. The total yield indicated that the plants with high K fertilization never really "caught up" since total yield was also decreased with high potassium fertilization, although the decrease was not statistically significant. The decrease in growth and yield was assumed to be the result of an excess salt and/or unbalanced ion effect.

The influence of K fertilization on Brix is shown in Table 3. Potassium fertilization did not cause any significant change in Brix. The addition of different amounts of K did not have any visual influence on fruit stem scar size, netting, internal flesh color, flesh depth, or dryness of fruit cavity.

The relationship between cation composition of the cantaloupe leaves and K application is shown in Table 4. There was very little influence on cation uptake by the plants with K fertilization. In many cases Mg uptake is reduced by large amounts of K, especially where Mg is slightly limiting (4). This was not the case, however, in this experiment and Mg uptake remained rather constant. There was a consistent but insignificant decrease in zinc concentration in the leaves with increased K rates but the decrease was not of sufficient magnitude to decrease yields or cause zinc deficiency symptoms. This K-Zn interaction has been noted before in grain sorghum (3).

The data from this study indicate that K fertilization is not needed

Table 1. Chemical composition of the Willacy fine sandy loam soil used in the study (0-6 inch depth).

		Pounds/acre			
	pH	*K*	*Mg*	*Na*	*Ca*
Willacy f.s.l.	7.9	1092	789	98	>4400

Table 2. Influence of potassium fertilizer on yield of cataloupes grown on Willacy fine sandy loam.

	Pounds of K/acre				
	0	*20*	*40*	*60*	*200*
			Crates/acre		
First 5 harvests					
45's	40.7 a*	45.8 a	39.8 a	30.5 a	6.8 b
36's	39.2 a	39.2 a	22.3 b	21.2 b	11.6 b
27's	29.7	22.6	17.0	16.9	12.7
Total	109.6 a	107.6 a	79.1 ab	68.6 b	31.1 c
			Crates/acre		
Second 5 harvests					
45's	34.8	42.4	33.0	33.9	34.8
36's	29.7	31.8	46.6	37.1	48.8
27's	24.0	15.5	25.4	25.4	46.6
Total	88.5	89.7	105.0	96.4	130.2
			Crates/acre		
All harvests	198.1	197.3	184.1	165.0	161.3

* Means in a row not having the same letter beside them differ significantly at the 5% level.

Table 3. Brix of cantaloupe grown on Willacy fine sandy loam with five potassium rates.

Pounds of K/acre	*Brix°*
0	11.0
20	10.5
40	10.6
60	10.8
200	10.8

Each value represents the mean of 16 observations.

Table 4. Cation composition of cantaloupe leaves growing on Willacy fine sandy loam with five levels of potassium fertilizer.

	Sampled at 56 days growth					*Sampled at 80 days growth*				
Pounds of K/acre	*K %*	*Mg %*	*Zn ppm*	*Mn ppm*	*Fe ppm*	*K %*	*Ca %*	*Zn ppm*	*Mn ppm*	*Fe ppm*
0	2.55	0.62	49	44	245	2.78	4.38	38	58	258
20	2.46	0.56	42	41	248	2.63	4.46	38	61	221
40	2.48	0.61	36	46	217	3.07	4.32	37	53	262
60	2.58	0.63	42	46	226	2.96	4.59	35	60	242
200	2.30	0.68	40	53	288	2.94	4.61	33	60	276

Mean of 4 replications.

on Willacy fine sandy loam soil. This could also be extended to include other soils of similar clay type, cation exchange capacity and K content. Since detrimental effects may be obtained from the use of more than 40 pounds per acre of K on soils of the above described type, caution should be used when applying K fertilizer to many soils of the Lower Rio Grande Valley where cantaloupe are to be grown.

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The Influence of Depth of Planting on Stolon Development in the Irish Potato

JOE M. ERNST, BRUCE A. PERRY, and H. T. BLACKHURST

Texas A&M University

Department of Soil and Crop Sciences

Abstract: The depth of planting has a significant influence on the location and number of developing stolons. Seed pieces were planted in one-fourth inch gravel at depths of 3, 5, and 8 inches in ten-inch plastic pots. The number and position of stolons were determined after sixty-seven days of growth. There was a significant influence of the depths of planting on the position of developing stolons on the lower three inches of the main axis and each of the three depths, but there was no significant difference in the number of stolons produced in this area. There were significant differences at the one percent level between both number and position of stolons on the entire main axis of the three different depths.

INTRODUCTION

The development of stolons from the vertical underground stem of the potato is a result of various environmental conditions, of which light exclusion is essential. The arrangements of the stolons on the main axis is generally five-ranked. Clark (1) states that the development of the stolons begins comparatively early in the growth of the plant, usually within ten days after the plant has appeared above the medium.

According to Plaisted (6) the stolons arise from auxilliary buds, progressing upward from lower nodes near the tuber piece. This tuber formation indicates acropetal development of stolons and tubers. Page (5) noted that stolons arise in acropetal succession as the plant develops. This statement suggests that the subterranean nodes must attain a certain degree of maturity before the stolons are initiated.

There are no specific recommendations for a depth to plant tuber pieces that will produce equally good results under all conditions. Seasonal, cultural, and climatic conditions that prevail during the growing season are determining factors. There are various recommended depths. Thompson (9) recommends between two and six inches, shallower for heavy soils and deeper for light soils. Kehr (2) states that tubers developed at two and a half to five inches under favorable conditions produce high quality tubers. Apparently there has been no attempt to relate the depth of planting to the location and development of tubers. In correlating the depth of planting with the location and development of stolon-bearing tubers, the influence of depth of planting on the production of tubers may be determined.

MATERIALS AND METHODS

Seed pieces of Norgold Russet were selected within a weight range of 1.5 to 2.5 ounces, and were planted in one-fourth inch mesh gravel medium in ten-inch plastic pots. Only one stem per seed piece was allowed to emerge. Separate pots were established for depth of planting treatments at three, five, and eight inches. There were fifteen pots for each treatment with an average of two plants per pot. The forty-five pot cultures were maintained under greenhouse conditions, and all received a complete fertilizer solution daily.

The following data relating the position of the stolon was recorded: age of the plant, node distance from tuber piece, number of developing stolons per plant, and the depth of planting. These data were recorded on each of the thirty plants representing the three depths at sixty-seven days.

All data were subjected to the analysis of variance, and significance (4, 7, 8) was determined by Duncan's Multiple Range Test. With respect to stolon position, a modification of Duncan's Multiple Range Test was used which included an extension to group means with unequal numbers of observations (3). The unequal number of observations were the result of the inconsistent number of stolons per plant.

RESULTS AND DISCUSSION

There was a significant influence of the depths of planting on the position of developing stolons on the lower three inches at each of the three depths. After an analysis of variance revealed significance, a modified Duncan's Multiple Range Test showed a significant difference at the one percent level among all three depths.

The analysis of variance revealed that there was no significant difference in the number of stolons produced on the lower three inches of each of the three depths at the five percent level. This analysis showed that although there was a significant variation in position of the stolons on the lower three inches, there was no significant difference in the number of stolons being produced in this region. (Fig. 1).

The influence of depths of planting on stolon position in regard to the entire main axis of the three depths was also studied. An analysis of variance revealed a significant difference in the position of stolons relative to depths of planting. A modified Duncan's Multiple Range Test showed that all three depths were significantly different from each other at the one percent level.

The analysis of variance produced a significant difference in the number of stolons produced on the entire main axis of the three depths. Duncan's Multiple Range Test showed significant differences at the one percent level among all three depths. The greatest number of stolons per inch were produced at the three-inch depths. It was observed that there was a greater concentration of nodes on the lower regions of the main axis and a gradual increase in the internode length on the upper regions of the stem.

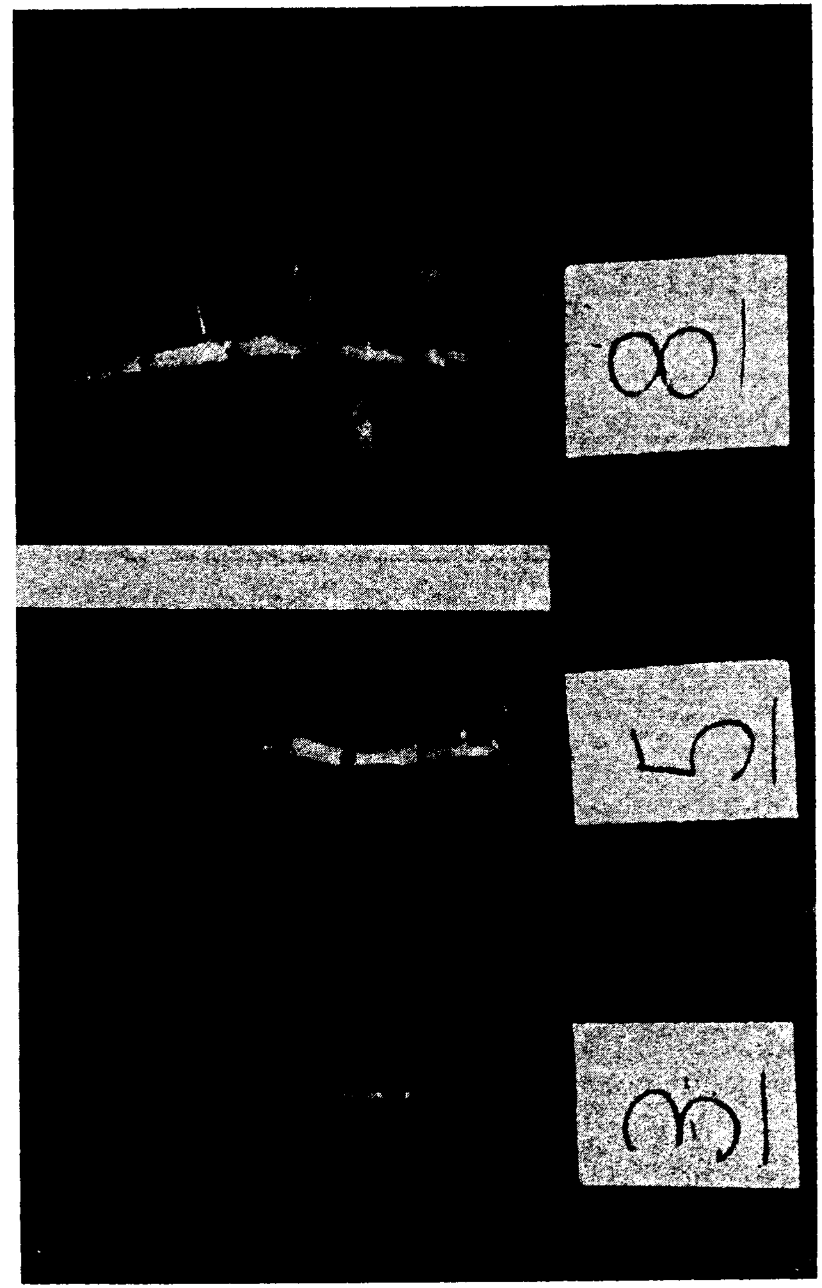

Figure 1. The subsurface portion of the main axis of the pot to representing three, five, and eight inch depths.

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Growth of Onions and Weeds with Herbicides and a Mulch[1]

Robert M. Menges and J. L. Hubbard[2]

Abstract: Soil surface, preemergence applications of 2-chloroallyl diethyldithiocarbamate (CDEC)[3] and dimethyl 2, 3, 5, 6-tetrachloroterephthalate (DCPA)[4] were oversprayed with a white-surfaced petroleum compound. The objectives were to study (1) the comparative growth of Palmer amaranth (*Amaranthus palmeri* S. Wats.), common purslane (*Portulaca oleracea* L.), and 'White Granex' onions; and (2) the influence of the white mulch on soil moisture and temperature. A total of 0.22 inches of rain fell in the first 6 days after treatment.

The activity of CDEC applied to the surface of the soil was increased with the white mulch, as indicated by increased weed control and yield reduction of onions. DCPA controlled weeds selectively in onions when there was light rainfall in unmulched soil but it controlled weeds less efficiently with the white mulch.

The white-surfaced petroleum mulch impaired the emergence of weeds and onions from the soil, conserved soil moisture, and decreased the soil temperatures. The data indicate that if the penetrability of a white-surfaced petroleum is improved, several advantages may be provided for production of vegetables in Southwestern USA: (1) the superior performance of certain herbicides; (2) conservation of soil moisture and thereby a reduction in the number of irrigations required for vegetable production and a reduction in salt content in the surface layers of soil; and (3) a reduction of soil temperatures for more efficient vegetable growth.

Conservation of herbicidal vapors by soil incorporation is suggested from decreasing temperatures with increasing depths to 2 inches in unmulched soil.

INTRODUCTION

Paper was used as early as 1930 as a mulch for the improvement of vegetable growth (5). The more recently discovered petroleum mulches are more durable than paper and have been reported to improve seedling emergence (6, 8); increase stand and yield (1); reduce soil moisture losses (4, 7) and soil crusting (1); increase soil temperature (8); or decrease soil temperature (7). In Southwestern USA, lower soil temperature would be desirable because vegetable seedlings sometimes succumb to extremely high soil temperatures.

Since the petroleum mulches enhance the growth of weeds as well as vegetables (10), herbicides have been incorporated in, or oversprayed with the petroleum compounds (1, 2, 6, 9, 10). Although other investigators reported that certain herbicides performed better when incorpo-

[1] The work was a cooperative project of the Agricultural Research Service, U. S. Department of Agriculture, and the Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas

[2] Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; and Agronomist, Texas Agricultural Experiment Station, Weslaco, Texas.

[3] CDEC formulated as Vegedex furnished gratis by Monsanto Company.

[4] DCPA formulated as Dacthal furnished gratis by Diamond Alkali Company.

rated within the mulch (6, 9), preemergence soil surface applications of several herbicides repeatedly performed more efficiently at this location when oversprayed with the petroleum mulch[5].

The primary objectives of the experiment reported herein were to study: (1) the comparative growth of onions and weeds with preemergence soil surface applications of 2-chloroallyl diethyldithiocarbamate (CDEC) and dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) oversprayed with a white-surfaced petroleum mulch; and (2) the influence of the mulch on soil moisture and temperature.

MATERIALS AND METHODS

Hidalgo sandy clay loam was disked, listed into beds and furrows, and then rotary-tilled. On the following day, September 17, 1963, the beds were firmed with a steel roller and the herbicides were sprayed to the surface of the bed plateaus. Four of 8 replications were then oversprayed with 700 gpa of a petroleum compound, EAP-2010, in 6-inch bands over the row areas[6]. After a preliminary field study with powdered $CaCO_3$, Kaolinite clay, polypropylene powder, talc ($H_2Mg_3(SiO_3)_4$), ground oyster shells, aluminum foil, translucent polyethylene film (4 mil.), opaque white plastic, and white plastic paint[7], the white paint was sprayed over the partially dried black surface of the petroleum mulch to reduce soil temperatures.

'White Granex' onions were seeded ½ inch deep in 2 rows spaced 11 inches apart on beds 40 inches wide immediately before premergence applications of herbicides. Treatments were replicated 4 times with methods of application assigned to main plots and herbicides to subplots. Each subplot consisted of 1 bed, 35 ft. long; data were recorded from 29 ft. of the row areas.

All plots were weeded 4 weeks after treatment. The average time required to weed each herbicide treatment was compared with that of the corresponding undisturbed check. The data are presented as percent week control. Furrows were periodically cultivated.

Six weeks after treatment, onions were thinned to a stand of 1 plant per 5 inches of row, and the soil was fertilized with 60 lb/A of N, as NH_4NO_3. Harvest data included total yield and bulb size of onions. Treatments had no effect on bulb size and data are unreported.

Soil temperatures were periodically recorded with copper-constantan thermocouples (24 gauge) and with thermisters. Soil moisture was recorded gravimetrically.

[5] Menges, R. M. 1963. U. S. Department of Agriculture, Agricultural Research Service, Crops Research Division, Annual Report: 81-83.
[6] EAP-2010 is a soft "paving" grade asphalt emulsified in water and was furnished gratis by Esso Research & Engineering Co., Linden, N. J.
[7] The paint was furnished gratis by Esso Research & Engineering Co.

RESULTS AND DISCUSSION

The weed population consisted of Palmer amaranth (*Amaranthus palmeri* S. Wats.) and common purslane (*Portulaca oleracea* L.). The white-surfaced petroleum mulch alone prevented the emergence of many weeds because the overspray of white paint reduced the penetrability of the film (Table 1). The mulch retarded emergence, tended to reduce stand, and significantly reduced the yield of onions. Direct inhibition of onion growth is indicated since the increase in weed control with unmulched, weeded checks was small. In the development of mulches for certain vegetable seedlings which lack even the penetration capacities of the onion, penetrability of mulches should be carefully considered.

CDEC controlled weeds more efficiently when oversprayed with mulch but the accompanying yield reduction in onions illustrates the lack of sufficient selectivity when vapors are trapped in the soil (Table 1). DCPA, wettable powder formulation, controlled weeds more efficiently without mulch, however, and had no effect on yield regardless of mulch. The data agree with those reported by Cialone in 1964 as regards the improved performance of carbamate herbicides, including CDEC and poorer performance of wettable powder formulations, including DCPA, with a petroleum mulch (2). Rainfall (0.22 inches) during the first 6 days after treatment probably afforded herbicide penetration into soil, and may thereby have enhanced unmulched applications of DCPA. The mulch was undoubtedly more effective in trapping vapors of CDEC compared with light rains on unmulched soil.

The white-surfaced mulch was more effective than a black mulch in the conservation of soil moisture (Table 2).

Table 1. Control of Palmer amaranth and common purslane and the yield of onions with preemergence, soil surface applications of herbicides and a petroleum mulch.

	Rate	Percent weed control[a]		Total yield (lb) per plot	
Herbicide	*(lb/A)*	*Mulch*	*No mulch*	*Mulch*	*No mulch*
DCPA	4	83	95	23.6	30.3
	8	84	95	28.2	27.7
CDEC	3	85	73	22.1	30.0
	6	91	84	19.0*	28.6
None, weeded check			88		29.9
None, unweeded check		79[b]		25.1	22.5*
LSD, 5%			9		3.6

[a] Weeding time.
[b] 'Mulched' was compared with 'no mulch' unweeded check. All 'mulched' checks were left unweeded to maintain the mulched surface.
* Significantly different from the corresponding weeded check.

The surface temperature of the white-surfaced mulch was considerably lower than those of the black mulch or unmulched soil (Table 3). The same relationship existed at the ½-inch depth in soil or the onion seed depth. The conservation of herbicidal vapors with soil incorporation is suggested from decreasing temperatures with increasing depths to 2 inches in unmulched soil.

It is conceivable that white-surfaced petroleum mulches may provide several advantages in the production of vegetables in Southwestern USA: (1) superior performance of certain herbicides; (2) conservation of soil moisture and thereby a reduction in the number of irrigations required for vegetable production and a reduction in salt content in the surface layers of soil; and (3) a reduction of soil temperatures for more efficient vegetable growth.

Table 2. Effects of black and white petroleum mulches on moisture in the surface 2 in. of a furrow-irrigated Hidalgo sandy clay loam during the first 25 days after herbicide and mulch applications in onions.

		Percent of field capacity[a]						
	Soil depth	Days (no.) after treatment						
Soil cover	*(in.)*	*0*	*5*	*8*	*12*	*18*	*21*	*25*
Black mulch	0 -¼	—	—	89	69	89	69	45
	1½-2	—	—	89	69	94	74	50
White mulch	0 -¼	—	—	94	84	104	84	50
	1½-2	—	—	99	84	99	89	79
None	0 -¼	20	173	54	35	79	20	20
	1½-2	25	94	79	54	89	79	50

[a] Each figure is the average of 2 replications and was rounded off to the nearest whole number for presentation. Field capacity 20.2%. Plots were furrow-irrigated 1 and 16 days after treatment. Recorded rainfall: 0.09, 0.04, 0.09, and 0.09 in. 1, 5, 6, and 18 days after treatment, respectively.

Table 3. Effects of black and white petroleum mulches on temperature (F) in the surface 2 in. of a Hidalgo sandy clay loam at 3 PM on the 12th day after herbicide and mulch applications in onions.

		Temperature at 3 PM					
		Soil depth (in.)					
Recording source	*Soil cover*	*0*[a]	*0*[b]	*⅛*	*½*	*1*	*2*
Thermister	Black mulch	126					
	White mulch	99					
	None	128					
Thermocouple	Black mulch		121	120	121	119	108
	White mulch		105	106	105	104	103
	None			116	111	109	105

[a] Surface temperatures were recorded by thermisters with a Stull-Hardy HL 4 Radiometer.
[b] Thermocouples within the petroleum layer. The unshaded ambient temperature was 113 F.

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Influence of Storage Temperature on the Respiration Rate of 4 Horticultural Groups of Southern Peas (Vigna Sinesis)

D. R. Paterson, H. T. Blackhurst and E. E. Burns[1]

Abstract: Over a three days storage period at 10°, 20°, and 30°C. there is a significant difference in the rate of respiration of the Purple Hull Pea when compared with the Cream, Cream Crowder and Blackeye groups of *Vigna sinesis.*

Vigna sinesis is an important source of food in the Southern States. Several studies have been made to determine biochemical changes which occur during growth and development of the crop (1, 4, 5, and 6). Non-refrigerated southern peas lost ascorbic acid and non-reducing sugars more rapidly than those refrigerated for the same length of time (6). Non-refrigerated peas began to lose their non-reducing sugars and ascorbic acid immediately after harvest, while refrigerated peas lost these same constituents more slowly (6). There was a decrease in the percent moisture, protein, and total and reducing sugars as the age of the pea increased (5). Relatively little reducing sugar has been found in southern peas (5). A 36 percent decrease in total sugars occurred between the time the seed could be separated from the pericarp and two days later (5). Bowers and Kattan (1) showed that changes in maturity were accompanied by changes in dry matter, alcohol insoluble solids (AIS), and Hunter b+Values. Gates et. al. (4) constructed a nomograph whereby the character score of southern peas could be estimated by a comparison of the shear resistance and AIS. Paterson and Blackhurst (7) demonstrated that supplemental irrigation increased the yield of Purple Hull No. 5 peas to a lesser degree than the Cream No. 8 or Extra Early Blackeye varieties.

Wolfenbarger and Correa (8) indicated that the Purple Hull group is damaged less than other horticultural groups by the cowpea curculio, *Chalcodermus aeneus* Boh. The commercially available varieties of southern peas can be arranged in 13 horticultural groups based almost entirely on seed size, shape, color and color patterns. The only exceptions are in those varieties comprising the Purple Hull group (2).

The purpose of the study reported here was to determine the effect of storage temperature on the CO_2 evolution of four horticultural groups of southern peas.

[1] Associate Professor, Professor, and Associate Professor, respectively. Texas A&M University, College Station, Texas.

MATERIALS AND METHODS

Purple Hull No. 12, Cream Champion, Cream Crowder SP36 and Blackeye SP51 varieties of southern peas were harvested at optimum green shell stage of maturity (2) on July 2, 1963. Three varieties of uniform samples of approximately 300 grams of each variety were placed in respiration chambers at 10°, 20°, and 30°C.

Carbon dioxide (CO_2) production was measured daily over a four day storage period (3). The above method was modified in that the humidified air passed over the peas was not freed of CO_2, and the indicator solution was renewed for each determination. The air entering the chamber was assumed to contain 0.03 percent CO_2 at all times and this correction was applied in all calculations.

RESULTS AND DISCUSSION

At 10°C. there was a highly significant difference between the Purple Hull No. 12 and the other three southern pea varieties in their rate of respiration (Figure 1). This variety had a higher rate of respiration the first day in storage and decreased less than the other horticultural groups over the four day storage period. At the end of the fourth day at 10°C. all of the varieties were still in a good marketable condition.

There was not only a significant difference in respiration rate due to variety, but also a highly significant variety interaction with storage time at 20°C. (Fig. 1). Again the respiration rate of the Purple Hull No. 12 declined more slowly than for the other three varieties until the second day of storage. There was a rapid increase in CO_2 evolution from the Cream Champion, Cream Crowder SP36 and Blackeye SP51 after two days at 20°C. (Figure 1). After two days at this temperature all lots of peas were unfit for fresh market.

There was no significant difference in the respiration rate due to variety at 30°C. (Fig. 1). However, there was a highly significant variety times days in storage interaction at this temperature. There was a rapid increase in CO_2 evolution from the Cream Champion, Cream Crowder SP36 and Blackeye SP51 beginning after only one day of storage at 30°C. (Fig. 1). The respiration rate of the above three varieties rose to a peak after three days in storage and then declined rapidly. At 30°C. the respiration rate of the PH No. 12 variety declined sharply after the first day of storage then rose rapidly during the second and third days of storage. After only one day at 30°C. all four varieties of southern peas were unmarketable.

As noted earlier there is a considerable difference in the response of the Purple Hull horticultural group of southern peas, both to irrigation and resistance to insect damage when compared to other horticultural groups of *Vigna sinesis* (7, 8). This report indicates a possible physiological basis for such conclusions.

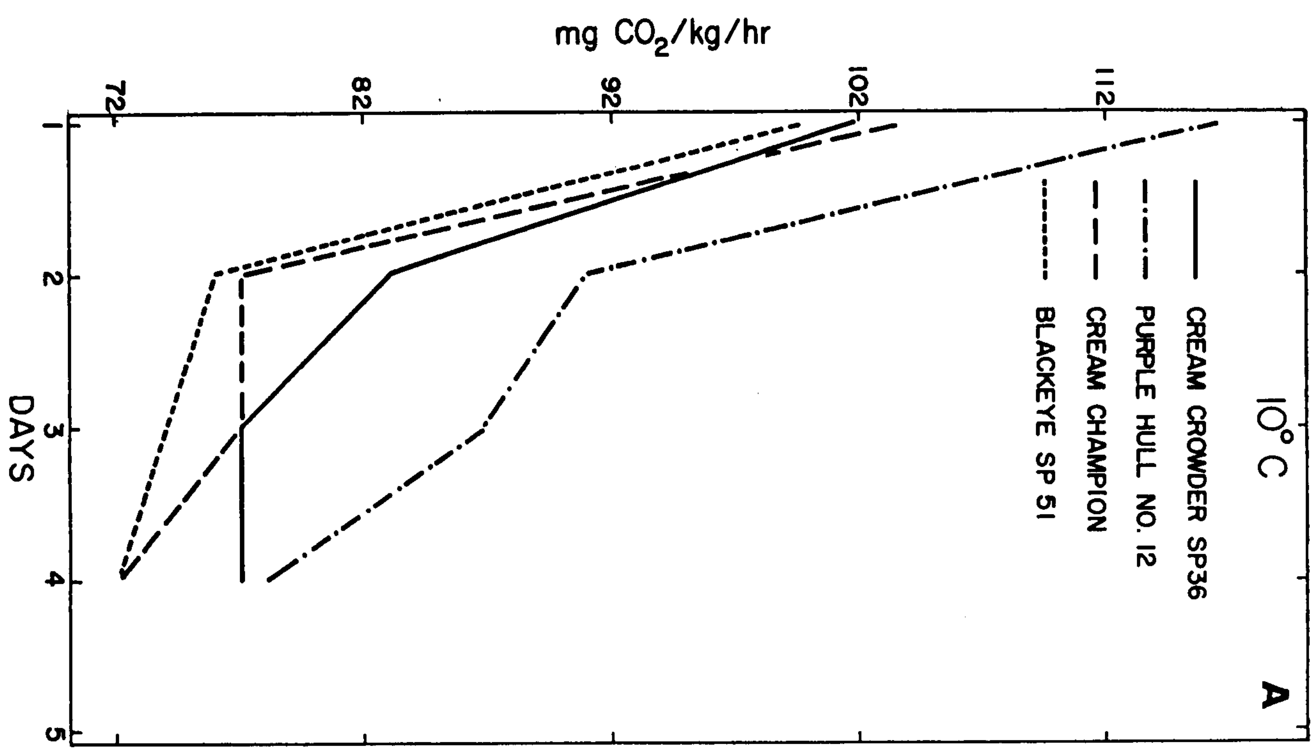

Figure 1A. Effect of Temperature and Time in Storage on the Respiration Rate of 4 Horticultural Types of Southern Peas.

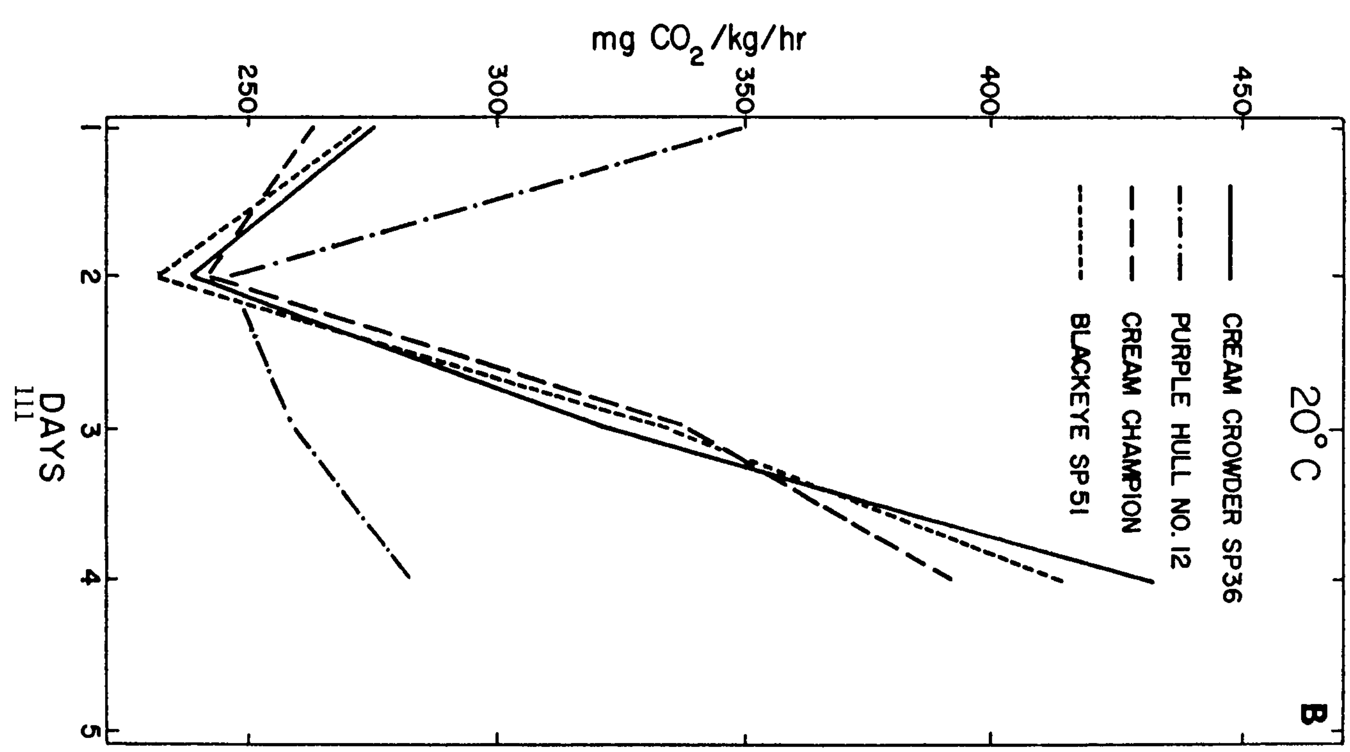

Figure 1B. Effect of Temperature and Time in Storage on the Respiration Rate of 4 Horticultural Types of Southern Peas.

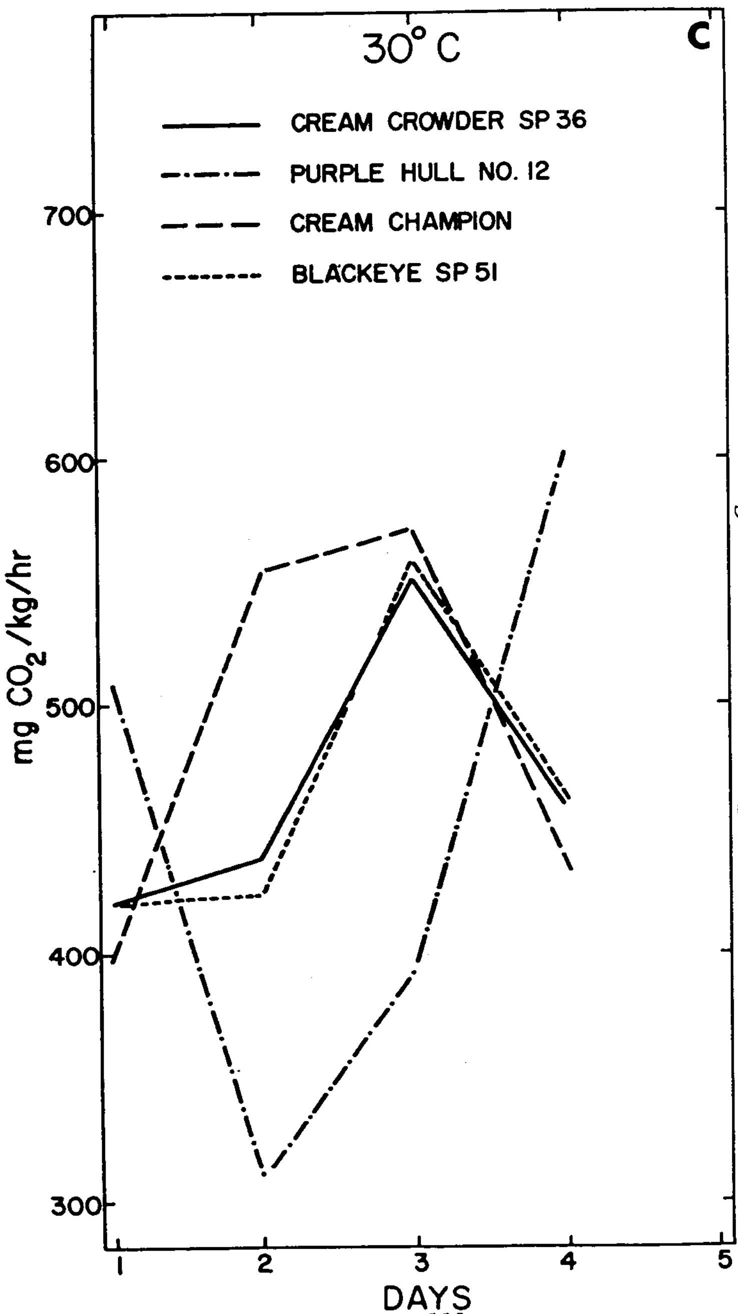

Figure 1C. Effect of Temperature and Time in Storage on the Respiration Rate of 4 Horticultural Types of Southern Peas.

L. S. D.	A 10°C		B 20°C			C 30°C	
	Var	*Days*	*Var*	*Days*	*Var x Days*	*Days*	*Var x Days*
5%	4	4	26	26	53	36	71
1%	6	6	—	36	72	49	97

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Peeling Tomatoes by Submerging in a Hot Solution of Calcium Chloride

Thomas S. Stephens, Guadalupe Saldana and Francis P. Griffiths[1]

Abstract: A small laboratory model tomato peeler capable of submerging tomatoes for a definite interval of time in a boiling calcium chloride solution has been constructed and its operation described. Tomatoes subjected to a high temperature calcium chloride solution in the peeler until the skin ruptured then allowed to remain in the solution an additional 5, 10, 15 and 20 sec continued to absorb calcium. When the cover juice was prepared from the tailovers from tomatoes which had been peeled in a calcium chloride solution, it added an excess of calcium and resulted in a tough canned product. Cover juice prepared from tomatoes not submerged in calcium chloride, when added to tomatoes which had been peeled in calcium chloride, did not cause the calcium content of the tomatoes to exceed the .026% allowed by the Food and Drug Administration. These tomatoes were firm but not tough and their favor was not impaired by the increased calcium. The caramelization of the dissolved solids from the tomatoes in the boiling calcium chloride solution was the most troublesome problem encountered in attempting to use the calcium chloride peeling technique in a commercial canning plant.

Chico and M-66 varieties of tomatoes peeled in calcium chloride and used in a canned seasoned salad (specialty) pack were firm and crisp but were not tough. The total amount of calcium in the canned product did not exceed the permissible amount.

INTRODUCTION

The addition of calcium chloride to cans of tomatoes in order to firm the fruit has been a commercial practice for a number of years (6). Kertesz *et al.* (5) recommended that calcium chloride be added to the can of tomatoes, either prior to closing and processing, or that the peeled tomatoes be dipped into a solution of calcium chloride before they were filled into the cans. Both methods serve to firm the tomatoes, but the firming action takes place after the tomatoes have undergone the rough handling at the peeling tables.

Childs *et al.* (2) stated that a concentration of approximately 60% calcium chloride boiling at 280°F gave the best separation of the peel from the rest of the tomato and the exposed tissues were firmer than fruit not treated with calcium chloride.

Heddins (3) demonstrated that a calcium chloride solution of such density that it could be heated to 250°F was very effective in removing the peel from La Bonita, Chico and Homestead varieties of tomatoes and samples canned from these tomatoes were firm. Because of the nature of his work, it was necessary that his samples be prepared in small lots and it was impossible for him to determine the amount of calcium the tomatoes would absorb from the peeling solution.

[1] Food Technologist, Physical Science Technician, Chemist in Charge, Food Crops Utilization Research Laboratory, ARS, USDA, Weslaco, Texas.

The purpose of this investigation was 1, to construct a tomato peeler capable of submerging tomatoes for a definite interval of time in a boiling calcium chloride solution; 2, to hold the fruit in the calcium chloride solution for increasing intervals of time after the tomato skin ruptured to see if the tomatoes would continue to absorb calcium; 3, to cover the tomatoes with juice prepared from the skins, cores and mashed or broken tomatoes which had been peeled in calcium chloride to determine the effect on the canned product; 4, to test the feasibility of using the calcium chloride peeling procedure in a commercial canning plant; and 5, to determine the effect of calcium chloride on firmness, flavor, and calcium content of tomatoes which had been peeled in a calcium chloride solution and canned as a seasoned salad (specialty) pack.

EXPERIMENTAL METHODS

Laboratory model tomato peeler.

The peeler shown in Fig. 1 was patterned after the sweet potato peeling machine described by Arthur and McLemore (1). A tank 19 in. long, 13 in. wide, and 10 in. deep was constructed of ¼ in. sheet

Figure 1. Laboratory model tomato peeler.

metal to hold the calcium chloride solution. A gas burner approximately 6 in. in diameter was mounted beneath the tank in such a manner that the flame could be adjusted.

A metal drum which rotated within the tank was 18 in. in diameter and 12 in. long, with eight perforated equally spaced baffles welded inside the drum. The sides of the compartments formed by the baffles were tilted in such a manner that the tomatoes entering one side of the peeler were pushed under the calcium solution and held submerged, then lifted from the solution on the opposite side of the peeling tank. A curved perforated piece of steel, 1/16 in. thick, was welded in the tank which closely fitted under the drum to hold the tomatoes in the compartments. A motor with variable speed drive was attached to the drum so the speed of rotation of the drum could be adjusted during operation.

To operate the peeler a 50:50 W/W calcium chloride solution was prepared and the tank filled to within ½ in. of the top. The calcium chloride used was Columbia P.P.G.,[2] regular flake 77-80% calcium chloride, technical grade. The solution was heated to boiling and the temperature adjusted to 250°F ± 2° (3) by adding small amounts of calcium chloride or water, depending upon which was necessary. Evaporation of water or loss of calcium chloride from the solution was adjusted each time the temperature fluctuated.

Small samples of tomatoes were placed in the peeler and the speed of the rotating drum adjusted so the skin of most of the tomatoes was ruptured as they appeared above the solution on the opposite side of the rotating drum. The term "rupture" is used in this case to mean the skin is completely removed from the tomato except for small pieces which adhere to the stem scar and around blemishes.

When the speed of rotation of the drum of the peeler was adjusted so that the tomatoes were submerged 27 sec, it required 5 sec for the baffle of the drum to completely submerge the tomatoes under the solution and an additional 8 sec were required for the baffle to lift the tomatoes from the solution. A 40-sec (5+27+8) interval is the minimum time, using this machine, that can be used to peel Chico or M-66 varieties of tomatoes. The tomatoes dropped from the peeler onto ¼ in. mesh hardware cloth and were immediately sprayed with a large volume of cold water at approximately 40 lbs pressure to remove free skin and excess calcium chloride. Any adhering skin and blemishes were removed by hand and the tomatoes washed again.

Calcium chloride absorption.

Six samples of Chico variety tomato were selected from about 50 pounds of tomatoes. Each sample consisted of 30 fruit selected as nearly

[2] Use of a company and/or product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

as possible to be the same size and maturity. The first sample remained in the calcium chloride peeling solution a total of 40 sec. The skin on two fruit of this sample did not rupture. The speed of the rotating drum of the peeler was decreased by 5 sec intervals so the second sample remained in the solution 45 sec, the third 50 sec, the fourth 55 sec (one fruit did not rupture) and the fifth 60 sec. The sixth, or control sample, was hand peeled without the calcium chloride treatment. The skin on all the tomatoes ruptured with the exception of those designated in treatments one and four. After peeling, each 30 fruit sample was blended 3 min in a Waring Blendor[2] and duplicate samples removed for calcium determinations. Another six samples of tomatoes were removed from what remained of the 50-lb lot of tomatoes, and the procedure repeated. The skin on three fruit of treatment one did not rupture, all others ruptured in the times treated. The percent calcium was determined on these samples of tomatoes and shown in Table 1.

Effect of cover juice.

Chico variety tomatoes were selected for uniform size and maturity and divided into four equal lots. The first lot of tomatoes was dipped one minute in boiling water, peeled, and 12 No. 300 plain cans filled with whole tomatoes. These cans of tomatoes were covered with juice prepared from whole tomatoes which had been crushed and heated as rapidly as possible to 180°F in a steam kettle. The juice was extracted with a Langsenkamp[2] laboratory-type paddle finisher operating at 1100 rpm, and fitted with a .020 in. screen. This juice is referred to as "plain" juice.

The second lot of tomatoes was peeled using calcium chloride in the laboratory peeler. The peel trimmings and pieces of these tomatoes were saved for future use. Twelve cans were filled with whole peeled tomatoes, then covered with plain juice.

The third lot of tomatoes was peeled using the same calcium chloride solution used for the second lot. The peel, trimmings and pieces of these tomatoes were mixed with the material saved from the second lot. The

Table 1. Percent calcium in tomatoes held in peeling solution after skin ruptured.

Time in peeling solution (sec)	First trial Calcium (%)	Second trial Calcium (%)
40	.044	.033
45	.056	.062
50	.048	.036
55	.054	.048
60	.076	.091
0 Control (fresh toms)	.025	.026

juice was extracted from this material in the same manner as the plain juice which was used to cover lots one and two. This juice is referred to as "tailover" juice and would approximate the juice collected by some canning plants from the broken tomatoes, pieces, peels and trimmings which tail over the ends of the belts which transport the tomatoes to the women engaged in peeling. Twelve cans were filled with the third lot of tomatoes and covered with the tailover juice.

The cans of tomatoes of the three lots were heated in an exhaust box to a center-can-temperature of 160°F, closed and processed 25 min in boiling water, then cooled in water.

The fourth lot of tomatoes was blended 3 min in a Waring Blendor[2] and used for the determination of percent calcium in the fresh tomatoes.

After approximately one month storage at 70°F, the cans of tomatoes were analyzed for the percent calcium in the tomatoes and juice. These results are reported in Table 2.

Commercial application.

A large rotary drum peeler similar to the laboratory model used in this investigation was constructed by a local canning plant. The rotary drum was 6 feet in diameter, containing eight compartments, each capable of holding about 4 field boxes, or 240 lbs of tomatoes. The tank was constructed of ¼ in. steel and was 4 feet wide, 4 feet deep and 7 feet long. A steam coil was mounted in the bottom of the tank, and the necessary valves and gauges to maintain a constant temperature mounted on the tank.

The peeler was charged with all of the calcium chloride available at the canning plant. The amount was sufficient to raise the boiling point of the solution to 240°F. The tomatoes remained in the solution for about 45 sec. The peel on a portion of the tomatoes did not rupture, therefore it was necessary to hand-peel these tomatoes. Tomatoes whose peel was ruptured, as well as those which had not ruptured, were combined and canned. The cover juice was extracted in a paddle finisher from the tailovers. Cans of these tomatoes were opened for sensory evaluation and found to be tough. Because of this, two-pound samples of tomatoes were collected along the processing line for calcium determinations to find out if the canned tomatoes were picking up too much calcium from the peeling solution or from the cover juice, or both. A sample of fresh tomatoes was collected from the inspection table before the calcium chloride peeling operation. Two samples were collected after the peeling operation; one from those tomatoes which had ruptured peels, and one from those which did not rupture. A sample was also obtained of juice made from the tailover material. The percent calcium was determined on each sample of tomatoes and juice and reported in Table 3.

Canned seasoned tomatoes (specialty pack).

The laboratory peeler was installed in a local canning plant and two

lots of Chico variety tomatoes and one of M-66 were peeled, seasoned and canned. Highly colored, firm tomatoes were hand picked from the processing line to make sure only the most uniform tomatoes were used. About 1000 g of fresh tomatoes were hand peeled and set aside for the control sample.

The tomatoes were subjected to the calcium chloride solution 40 sec as previously mentioned in the discussion of the operation of the peeler. As the tomatoes emerged from the peeling solution, they were thoroughly washed and any adhering skin removed by hand. Each tomato was cut into slices approximately 3/8 in. thick and 30 No. 303 (303× 406) enameled cans were filled with about 9 ounces of sliced tomatoes into each can. The spice mixture, composed of vinegar, oil, salt and seasoning, was added to each can, then hot 150°F plain tomato juice added to fill the can. A 500 ml sample of juice was set aside for calcium determination.

The cans were closed on a steam closing machine with a center-can-temperature of 110-112°F, and processed 15 min at 210° F. The cans were stored approximately one month at 70°F, then opened and analyzed for the percent calcium in the tomatoes and juice.

A sensory panel of 7 members was asked to evaluate for firmness and flavor the cans of seasoned tomatoes peeled in calcium chloride. Seasoned tomatoes which had been peeled in hot water were used as a control sample.

Analytical methods.

The drained weight of the canned tomatoes was determined according to the procedure outlined in the United States Standards for Grades of Canned Tomatoes (7). Percent calcium was determined by using the EDTA (disodium dihydrogen ethylenediamine tetraacetate dihydrate) method outlined by Johnson and Ulrich (4).

RESULTS AND DISCUSSION

Effect of increasing the time interval that the tomatoes remained in the calcium chloride solution after the skins of the tomatoes ruptured is given in Table 1. As the time interval increased from 40 to 60 sec the percentage calcium in the tomatoes increased from .044 to .076% for the first determination, and .033 to .091% for the second determination.

The increase in calcium uptake was rather uniform from the 40 to 60 sec peeling time, except for tomatoes remaining in the solution 45 sec. The percent calcium in both determinations was higher than the 50 or 55 sec peeling time. This increase in calcium percent could have been due to split tomatoes in these samples which allowed some of the peeling solution to be trapped in the locule of one or more tomatoes. It is probably a coincidence that this occurred in both samples submerged 45 sec and only in these samples.

The skin on most of the tomatoes ruptured after being submerged

Table 2. Effect of calcium chloride peeling and source of cover juice on calcium content of canned tomatoes.

Sample	Net wt. in can (g)	Drained tomatoes Wt. (g)	Drained tomatoes Ca. (%)	Drained tomatoes Wt. of Ca. (g)	Cover juice Wt. (g)	Cover juice Ca. (%)	Cover juice Wt. of Ca. (g)	Total amount: Ca. in canned toms. & juice (g)	Total amount: Natural calcium per can (g)	Permissible[4] amt. Ca. per can (g)	Calcium added (%)
1[1]	457	314	.019	.060	143	.021	.030	.090	.090	—	—
2[2]	462	346	.029	.101	116	.029	.034	.135	.090	.210	.010
3[3]	463	350	.061	.212	113	.067	.076	.288	.090	.211	.043

[1] Tomatoes peeled with hot water covered with plain juice.

[2] Tomatoes peeled with calcium chloride solution covered with plain juice.

[3] Tomatoes peeled with calcium chloride solution covered with tailover juice.

[4] The permissible amount of calcium for each can was determined by multiplying the net weight by .026% and adding the natural calcium in the tomatoes to the product.

Table 3. Percent calcium in tomatoes taken from the processing line of a local cannery.

Sample treatment	*Calcium (%)*
Fresh tomatoes	.024
After calcium cholride immersion, but peel did not rupture	.026
After calcium chloride immersion, peel ruptured	.045
Broken tomatoes, pieces, peels and trimmings from tomatoes subjected to calcium chloride (tailovers)	.064

about 27 sec, but it took a minimum of 8 sec additional time for the baffels on the rotating drum to life the tomatoes from the calcium chloride solution. Increasing the time interval of the peeling operation increases the time the tomatoes float in the peeling solution after their skins rupture. The amount of calcium taken up by the tomatoes could be reduced if the fruit was lifted from the peeling solution as quickly as possible after the skin ruptures on the majority of tomatoes.

Effect of adding tailover juice prepared from calcium chloride peeled tomatoes to cans of tomatoes which were peeled in calcium chloride is shown in Table 2. The tomatoes which were peeled in calcium chloride and covered with tailover juice contained .288 g of calcium in a No. 303 can, the net contents of which weighed 463 g. The permissible amount of calcium in this weight of tomatoes could be no more than .211 g. The definition and standards of the Food and Drug Administration state that, "calcium salts (may be added) in a quantity reasonably necessary to firm the tomatoes, but in no case such that the amount of the calcium contained in such salts is more than .026% of the weight of the finished canned tomatoes." Tomatoes peeled in calcium chloride but covered with plain juice contained .135 g of calcium in 462 g of tomatoes. The permissible amount ofcalcium for this weight of tomatoes would be .210 g. These data show that the tomatoes peeled in calcium chloride and covered with plain juice did not exceed the permissible amount of calcium but the tomatoes peeled in calcium chloride and covered with tailover juice from tomatoes peeled in calcium chloride exceeded the permissible amount.

Several problems were encountered by the local canning plant in using the calcium chloride peeling technique to peel tomatoes. The lack of uniformity in size and maturity and the number of broken fruit in each load caused some trouble. The caramelization of the dissolved solids from the tomatoes in the boiling calcium chloride solution was the most troublesome. It was impossible to remove all the split and

Table 4. Effect of calcium chloride peeling on calcium content of canned seasoned tomatoes (specialty pack).

Variety and Sample	Net wt. in can (g)	Drained tomatoes Wt. (g)	Drained tomatoes Ca. (%)	Drained tomatoes Wt. of Ca. (g)	Cover juice Wt. (g)	Cover juice Ca. (%)	Cover juice Wt. of Ca. (g)	Total amount: Ca. in canned toms. & juice (g)	Total amount: Natural calcium per can (g)	Permissible amt. Ca. per can (g)	Calcium added (%)
Chico											
1[1]		252[2]	.018	.045	196[2]	.014	.027		.073		
2	462[2]	258	.026	.066	204	.020	.040	.107		.193	.007
Chico											
1[1]		252	.017	.044	196	.014	.027		.071		
2	444	235	.031	.074	209	.022	.046	.119		.187	.011
M-66											
1[1]		252	.018	.044	196	.014	.027		.072		
2	433	241	.026	.062	192	.021	.040	.102		.184	.007

[1] Represents the fresh hand peeled tomatoes and the juice used to cover the samples which were canned.

[2] The difference in net weight in the cans of tomatoes and weight of tomatoes added to each can, plus the juice added, is due to the vinegar, oil and spices added to each can.

broken tomatoes from the sorting belt before they entered the peeling solution. At the end of the second day of operation, the calcium chloride solution had developed a burned sugar smell which was imparted to the tomatoes. A method of filtering or cleaning the calcium chloride solution needs to be developed.

Table 3 shows the percent calcium in the tomatoes collected from the processing line of the canning plant. Canned samples of these tomatoes were opened and tasted and found to be tough. Although the number of samples taken from the processing line was limited, the data indicates that the tomatoes were tough probably due more to the high calcium content, .064%, of the tailover juice which was added as cover juice than the extra calcium the tomatoes picked up from the peeling solution.

The results demonstrate again, as was demonstrated in the previous section of the paper, that it would be unwise to use tailover juice prepared from tomatoes peeled in calcium chloride as cover juice in cans of tomatoes which had been peeled in a calcium chloride solution.

The effect of calcium chloride peeling on the calcium content of Chico and M-66 varieties of tomatoes used in a canned seasoned salad (specialty) pack is given in Table 4. The addition of vinegar, oil, seasoning and plain tomato juice as the cover liquor did not add an excessive amount of calcium to the calcium chloride peeled tomatoes. The total amount of calcium in the canned seasoned tomatoes was therefore below the maximum amount allowed by the regulations of the Food and Drug Administration (8).

The M-66 variety was not as firm and crisp as either sample of Chico variety but was much superior to either variety of tomatoes which had been peeled in hot water. The members of the sensory evaluation panel could consistently choose the tomatoes peeled in calcium chloride and every member preferred these firm crisp slices. Slices from tomatoes peeled in calcium chloride retained their shape better and it was possible to get more of the tomato into the can than tomatoes which were peeled in hot water and then sliced. Peeling tomatoes in calcium chloride was an excellent way of preparing the fruit for a specialty product such as a canned seasoned salad pack. In the process, only firm, sound, fully ripe tomatoes were selected; therefore, the calcium chloride was used for a longer period of time before it became contaminated with the dissolved solids from the tomatoes.

ACKNOWLEDGEMENTS

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Possible Application of New Innovations in Vegetable Processing[1]

THOMAS S. STEPHENS[2]

Innovations in vegetable processing are of interest to people of the Rio Grande Valley because they may directly affect the agriculture of this area. Before considering what these are, let me mention some of the new ideas which are proposed to help feed our rapidly increasing population.

Dr. A. T. McPherson (7), an authority on chemical and biological production of food, has recently stated that either carbohydrates or fats could be made from petroleum (crude oil). Petroleum production by 1970 will exceed 2,000 million metric tons and only 3% of this would be used to close the food gap.

Other authorities have suggested that grass could be converted into human food or that various types of algae or mold would make excellent food. For some reason, I can't get overly excited about eating crude oil, grass or algae, but then I will probably have to eat them one of these days.

It probably will be the younger generation which will determine the foods I will eat. In the United States, one-half of our population is under 25 years of age (9). These young people are starting their homes. The husband and wife both must work to get their start, or maybe for some other reason. Whatever the cause, the foods they use must be more convenient; easy and quick to prepare. It is true the 35 to 49 year age group buys the most food, and they should – they have bigger families and higher incomes. But it is the market potential of the 18 to 34 year age group that many of our large food producers are looking to for their increases in profits.

I was telling a friend not long ago that now there is a product called "Avicel," a microcrystalline cellulose, which, when added to peanut butter will make the peanut butter free-flowing (2). It can be poured. He told me he likes his peanut butter as it is – sticky. I like my peanut butter sticky too, because peanut butter is supposed to be sticky. But just think of the thousands of bakers and candy manufacturers who will be able to "pour" the required amount of peanut butter into their

1 Presented at the Twenty-first Annual Horticultural Institute, Rio Grande Valley Horticultural Society, Weslaco, Texas, January 24, 1967.
2 Food Technologist, Food Crops Utilization Research Laboratory, ARS, USDA, Weslaco, Texas.

cake or candy mixes, to possibly create a new product, to satisfy the needs of this 18 to 34 year age group.

Last month I had the opportunity to attend the Conference on the mechanization of tomato production and the tomato breeders round-table at Purdue University. Speakers from California informed us that of the 4,700,000 tons of tomatoes harvested in the United States last year, California accounted for 3,200,000 tons and next year they expect to product 4,000,000 tons. They harvested most of those tomatoes by machine. Last year there were 385 to 400 mechanical tomato harvesters operating in California (4).

It seems that every phase of the vegetable industry is moving ahead very fast. As has been stated, it won't be long in some sections of the U. S., before one person seated at a large console of buttons on a computer will direct harvest, production, packaging and delivery with a minimum amount of labor and a minimum amount of time.

I'm reminded of the young Indian warrior who returned from the wars anxious to get ahead and make up for lost time. He said,

"me heap fast; me gettum horse can't be passed,
me gettum tepee, will last and last;
me gettum squaw, figure unsurpassed;
me gottum horse, tepee, nagging squaw,
now squalling brat;
alas, alas, me too darn fast."

I sometimes wonder if maybe our nation's speeded-up vegetable processing industry isn't like this Indian's life. However, one thing seems certain – we can't slow down now. To do so would be like trying to back up on a freeway.

In discussing briefly some of the new innovations in vegetable processing, I would like to group them under five methods of processing – 1, canning; 2, freezing; 3, freeze-drying; 4, dehydration; and 5, irradiation.

1. CANNING.

In the canning industry the use of "*hydrostatic cookers*" is speeding up the vegetable canning process (1). Instead of using retorts or pressure cookers which are batch operations, the canning plant operator can use the continuous hydrostatic cooker. The hydrostatic cooker is a large tank about 18 feet by 9 feet and 45 feet tall, filled with water and heated at the bottom. The height of the water column in the cooker regulates the pressure and temperature of the lower part of the cooker. Cans filled with beans, or peas, or tomatoes enter the top of the cooker and move down through the water. The warm water at the top slowly warms the vegetables and the hot water at the bottom cooks them; then the cans of vegetables move back up the cooker into the cooler water to cool the cans of vegetables. The cans are slowly heated and slowly cooled so there is a minimum of stress on the can.

More important, the process is continuous. It is not necessary to load and unload the baskets which are used in the pressure cooker. The cans of vegetables enter one side of the cooker and emerge on the other side cooked, cooled and dried ready for the label to be placed on the can.

Another new milestone is *aseptic canning*. Soup mixes, vegetable juice and other liquid products can be sterilized rapidly in heat exchangers and cooled rapidly to better retain their color, flavor and aroma. The products are then canned under aseptic conditions. By pumping juice through a tubular heat exchanger the juice can be heated much quicker than if placed in a can, then heated. The temperature can be increased rapidly up to the sterilization point, then cooled rapidly, thus avoiding cooked flavors. The juice is then canned aseptically. There is one advantage not often mentioned. The canning plant must be clean, because all it takes is one live bacterium in the can to cause that can to spoil.

At the Western Utilization Laboratory in Albany, California (14), scientists have found that they can lower the pH (increases the acid) of tomatoes with hydrochloric acid as the tomatoes are being crushed prior to the manufacture of juice products. This blocks the action of the enzyme pectinisterase. This is one of the enzymes that destroys the pectin, resulting in a tomato juice that is thin and watery. Heating and acidified, crushed tomatoes or the acidified juice permanently inactivates the enzymes. The acidified tomato juice is then neutralized with sodium hydroxide. The resultant juice has much better consistency and the yield of juice is increased. The sodium hydroxide reacts with the hydrochloric acid to form common table salt and water. The canner has a better product and more of it.

Another new product is Avicel-RC containing cellulose gum (5). A mayonnaise-type salad dressing can be prepared which will not break down or discolor when heated at 240° F. for 75 minutes. Thus it is now possible to sterilize in the can such products as potato salad, or other chopped vegetables. The housewife has a readily available salad without having to boil and chop potatoes and eggs, peel onions, or cut pickles.

2. FREEZING.

Moving from the field of canning, let us consider freezing preservation of vegetables. All of us have been eating frozen vegetables for a number of years. Some of you have noticed that in the past few years it has become possible to buy bags of frozen vegetables which have individually frozen pieces of vegetables in the bag. We still have the frozen block of vegetables in a box, especially the leafy vegetables, but where possible, more and more vegetables are being frozen as individual pieces. The trade refers to these vegetables as I.Q.F., or individually quick frozen. The housewife can use one serving or two, reclose the bag and put it back into the freezer for another meal. We may not realize it but these vegetables are probably a little better than the vegetables frozen in a solid block. Individually quick frozen vegetables must be handled properly from the processor to the consumer or they will thaw enroute and when stored in the retailer's cabinet, will re-freeze. Instead of being individually quick-frozen pieces, the vegetables will be a frozen block in the bag. This lets the purchaser know that the bag of vegetables has been allowed to thaw. It was not maintained in a frozen condition.

Individually quick freezing also makes it possible for the freezingplant operator to increase his production with fewer people handling the product. One Libby plant in Delaware has reported increasing production of green beans 400% and increasing yield 5% by changing from conventional freeze-in-the-box to individual quick freezing (3).

3. FREEZE-DRYING.

The preservation of vegetables by *freeze-drying* is a relatively new process. Freeze-drying is a process whereby the frozen vegetable piece is dried without being allowed to thaw. Those of you that have lived further north have probably seen the process take place when you dried your washing during freezing weather. It is about the same thing. The wet clothes freeze, then if they hang out long enough, they will dry. Vegetable pieces which are frozen, then dried, have small passage-ways into each piece where the ice crystals were removed. Those vegetable pieces retain their shape, color and flavor and rehydrate much better than conventionally dried vegetables. Those of you that have used some of the dehydrated soup mixes now on the market have probably used some freeze-dried vegetables.

The cost of freeze-drying is still high and not too great a volume of vegetables have been processed this way in the United States; however, the process is a very good one and will be used more as new techniques are developed. Recently, General Foods and the Nestle Corporation test-marketed freeze-dried coffee. Both companies report that the coffees are no more convenient than present instants, but they are earning repeat sales through sheer quality (8). The Irish Sugar Company is packaging freeze-dried vegetables and says they are selling well in Ireland, in spite of comparatively high prices, because the quality is recognized as outstanding.

Freezing with liquid nitrogen at a temperature of -320° F. is another new method of preserving vegetables. I'm sure most of you remember not too many months ago several of the leading magazines had advertisements stating that it was now possible to buy frozen tomato slices. These tomato slices had been frozen with liquid nitrogen. Some people said the tomato slices were not as good as fresh tomatoes because they were a little soft and not crisp. I don't exactly crave frozen tomato slices either, because I'm used to eating good, fresh Valley grown tomatoes. But just think of the volume of tomato slices that can now be used in the making of hamburgers and sandwiches. The frozen tomato slice gives the hamburger stand operator a constant supply. After placing a tomato slice on a hot piece of hamburger meat in a hot bun, it doesn't make too much difference if it is fresh or frozen.

Some say, that freezing cost will be too high with liquid nitrogen. It is calculated that it takes about one pound of nitrogen to freeze one pound of tomatoes at a cost of 5c per pound. This is high if compared with conventional freezing at .2 to .6c per pound (6). However, some of the large freezing companies have found that increased production offsets the increased cost of freezing.

4. DEHYDRATION.

One of the oldest methods of food preservation is dehydration. New techniques and different applications of old techniques have made it possible to introduce new dehydrated products to the housewife. Dehydrated Irish potatoes is one good example. After World War II, the word dehydration to most service men was a bad word. But the fantastic increase in sales of dehydrated white potatoes indicates some significant changes have been made (11).

The old double-drum drier which was not too satisfactory for some products, is now, through new methods, being used to prepare sweetpotato flakes, pumpkin flakes and carrot flakes. The Southern Regional Research Laboratory and North Carolina State University have developed a sweetpotato flake and a pumpkin flake which make excellent pies. The dried flakes look something like the breakfast food called bran flakes. To make an excellent sweetpotato dish, the housewife adds a little water and butter, then sprinkles marshmallows over the top. She places this dish in the oven until hot, then puts it on the table ready to eat. The advantages of such a product are numerous. All of the large size, small size, damaged potatoes and potatoes with strings can be used by the processor. The preparation and drying can be accomplished by a minimum number of people and of course it is quick and easy for the housewife to prepare.

We have worked with carrot flakes at the Food Crops Utilization Research Laboratory and have found it to be a very good product. A carrot flake product could be used in the baby food industry, or to add color to soup mixes or bread. And there may be other uses.

Another dehydration process is called "explosive puffing" (12). Vegetables such as white potatoes, carrots, beets and sweetpotatoes have been successfully puffed. The vegetable is cut into ⅜ inch dice and partially dried. The product is then loaded into a gun with a quick opening lid on it. The gun is heated until steam forms and pressure builds up inside the vegetable dice; then the lid of the gun is quickly opened and the vegetable dice blown from the gun. The sudden change in pressure causes the vegetable dice to puff, creating a porous type structure. Dehydration is then completed in tray driers, bins or belt trough driers. This is the same process that is used to make the breakfast food—puffed wheat or puffed rice. Puffed vegetables have one big advantage, it doesn't take long to rehydrate them and have them ready to eat.

There isn't too much to report concerning the preservation of vegetables by irradiation. An irradiation dose sufficient to sterilize vegetables also changes the flavor and aroma of most of them. So far, irradiation can be used to sterilize bacon, treat infested grain and fruit, inhibit sprouting in potatoes and pasteurize seafood. One thing I would like to report concerning irradiation is that near Spokane, Washington, a Nike missile site is being converted to an industrial radiation facility. The Nike site provides a 40 x 60 foot underground room deep enough for adequate shielding which will eliminate the cost of building heavily shielded radiation vaults above ground. This is important, of course, because we have a use for these very expensive out-of-date Nike installations (13).

I have been asked also to look into the crystal ball and comment on the application of these new processes to Valley vegetable processing. I have been accused of being one of the world's biggest pessimists. But I can't help being a little optimistic about Valley vegetable processing, because for no other reason statistics show the population of Texas during the past 20 years has increased 60% to over 11,000,000 people and there isn't any reason to believe this trend will slow down (10). In Brownsville, at the United Foods, Inc., formerly Pan-Am Foods, a large I.Q.F. machine has been installed to freeze blackeye peas, okra and other vegetable products. At the little town of San Carlos, just north of here, we have one of the first freeze-drying plants. At present, the plant is freeze-drying shrimp, meat patties, crab, mushrooms and other products. There isn't any reason to believe they will not include Valley vegetable products as the cost is reduced and demand warrants it. At Monte Alto there is the Valsing Freezing operation. I feel sure that in the future we will see hydrostatic cookers and aseptic canning lines in Valley canning plants.

I have to keep reminding myself that the Valley is a young agricultural and processing area. We are several years behind some other sections of the country, not by choice, maybe, but because of water conditions, labor conditions, and, of course, weather conditions. I do believe that in the future, maybe not next year nor the next, but before too many years, we will see more and more of the new innovations start as new innovations here in the Rio Grande Valley.

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Sidegrafting of Succulent Grapevine Tips onto Established Vines

C. O. Foerster, Jr.

Plant breeders are constantly searching for new techniques that can be used to bring seedlings or controlled crosses into production as soon as possible. This is especially true with grape breeders because depending upon the vigor of the seedling it may take two or more years to grow the plant large enough for fruit production.

The technique of side grafting succulent tips of grape seedlings onto canes of established vines resulted in cane growth of the grafts up to 30 feet in length in one season. Fruit production was obtained the next year after making the graft.

MATERIALS AND METHODS

Grape seed was planted in rows in February. In seventy days the seedlings were about 2½ inches tall and had 6 true leaves. The succulent tips were cut from the seedlings leaving two cotyledon leaves and one secondary leaf. The leaves were left so that the seedlings could produce a new top in case the graft died.

The grafts were prepared for insertion into the rootstock by making a long tapered cut on one side of the basal end of the scion. The base of the sloping cut ended in a feathered point.

The succulent tips were than side-grafted onto established plants with a diameter of ¼ inch or larger. A "T" shaped incision was made on the stock into the cambium layer with a sharp knife. The flaps of the bark were held back and the scion was carefully inserted into the opening with the pointed end down. Care was used in inserting the scion so that the entire cut surface of the graft wood was in contact with the cambium layer of the rootstock.

The scion and graft union then was wrapped with clear polyethylene tape. When wrapping the tape, a slight pressure should be applied so that the tape is tight enough to hold the scion firmly in place and exclude air from all cut surfaces.

Covering the graft union and scion with polyethylene tape created a micro-climate of even high humidity and temperature. This type microclimate facilitated rapid healing of the graft union.

The wrappings were left on the grafts from 14 to 21 days. When the tape was removed care was exercised so that the tender leaves of the tips were gradually exposed to the air. Gradual removal of the plastic is particularly important if the weather is hot and dry.

Figure 1. Grape seedlings of grafting size.

Figure 2. Completed graft.

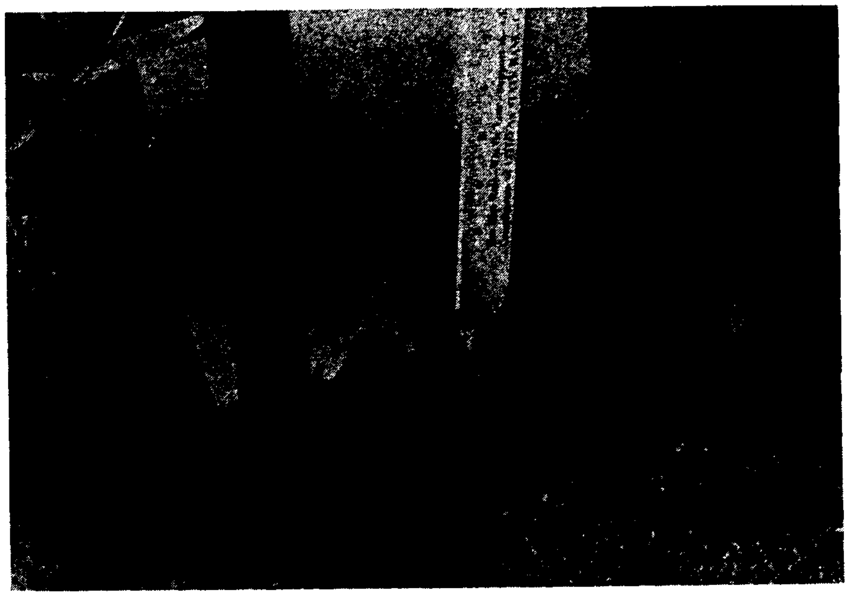

Figure 3. Grape seedling planted February, 1967. Picture taken June 1, 1967

Figure 4. Grafted April 1, 1967 from seedlings planted February, 1967. Picture taken June 1, 1967.

CONCLUSIONS

By side grafting tender tips of seedlings onto established grape vines, seedling grape vines or controlled crosses can be brought into production in one year from the time the graft is made.

This technique makes the waiting period for a grape breeder to make selections from crosses much shorter than by growing the seedling until it produces fruit.

Cane growth of up to 30 feet can be obtained in one growing season from side grafted tips onto an established grape vine.

The Description and Operation of a Machine for Peeling Avocados

Thomas S. Stephens[1]

Abstract: The construction and operation of a machine for peeling avocado fruit is described. The machine consists of two drums, both rotating downward toward the nip. One has a solid outside surface, the other has a perforated outside surface. Pitted avocado halves are placed one at a time with the seed cavity toward the perforated drum. As the drums rotate, the solid drum presses the meat of the avocado through the ¼ inch holes in the perforated drum. A doctor blade mounted inside the perforated drum cuts the meat from the peel, and a doctor blade on the outside of the perforated drum removes the peel.

INTRODUCTION

Avocados selected for fresh market distribution are as a rule choice fruit. Those fruit which do not meet market standards are eliminated at the packing house as culls. Most of the culls contain edible meat, but do not meet fresh market standards because of wind scars, damaged spots, small size or other physical defects.

The United States Department of Agriculture, Agricultural Statistics, (1) shows more than 500 tons of avocados were culled from fruit harvested in 1954, 875 tons in 1955, 1,125 tons in 1956, 545 tons in 1957, 400 tons in 1958, 950 tons in 1959, and 660 tons in 1964.

Products have been recommended (2, 3, 5, 6) which might profitably utilize the cull or surplus fruit, but until recently none of the recommended uses have been developed on a large commercial scale. Urbanek (7) reports that a frozen guacamole dip is being produced and offered in consumer test markets in Phoenix, Arizona, and some cities in Texas. Plans are underway to distribute the product throughout the United States.

The high cost of hand labor necessary to peel the avocado fruit has been one of the reasons for the lack of commercial interest in the development of processed avocado products.

The purpose of this report is to describe the construction and operation of a machine which will, in one operation, separate the peel from the avocado meat and at the same time cut the meat into short pieces suitable for use in salad mixes (guacamole). The machine is similar to the one described by Rathbun (4) which was designed to separate banana pulp from the peel.

[1] Food Technologist, Food Crops Utilization Research Laboratory, ARS, USDA, Weslaco, Texas.

DESCRIPTION OF MACHINE

The avocado peeling machine shown in Figures 1 and 2 consists of two rotating drums made of 15 gauge stainless steel, 16 inches in diameter and 4 inches wide. The surface of one drum is solid and the surface of the opposite drum is perforated with holes ¼ inch in diameter, with 1/16 inch or less of metal between holes. The holes are round and each hole is slightly leveled on the outside surface of the drum.

The bearings for the two drums are sprocket hubs from two bicycles. Two shafts ¾ inch in diameter are fitted through the bearings of each hub and a flange about 3 inches in diameter welded to one end of each shaft and a 5 inch V-belt pulley fastened to the opposite end of each shaft. The solid (press) drum is bolted to one flange and the perforated drum bolted to the other.

The hub supporting the perforated drum is mounted stationary on a frame constructed of 1 inch angle iron. The hub supporting the press drum is mounted on a hinged plate and the plate mounted on the frame so the two drums are in line. The hinged plate is held under spring tension and is attached to the frame in such a manner that the clearance between the drums is adjustable from 0 to ¼ inch. Both drums are attached with V-belts to a variable speed drive so that as the machine is operated the drums rotate downward toward the nip. Doctor blades are mounted both inside and outside the perforated drum as close to the contact area of the two drums as possible. A discharge shoot attached to the inside doctor blade curves down and extends outside the perforated drum. The outside doctor blade is mounted with the cutting edge about ⅛ inch lower on the perforated drum than the cutting edge of the inside doctor blade. A third doctor blade is mounted outside and near the bottom of the press drum to remove pieces of broken peel adhering to the surface. Triangular retaining plates are mounted on either side of the drums extending from the nip to the top of the drums.

OPERATION

To operate the machine the speed of the drums is adjusted with the variable speed drive to turn approximately 10 rpm. The avocado fruit is cut in half, the seed removed and each half inspected for damaged and discolored spots. The pitted avocado halves are placed one at a time on the perforated drum with the fleshy meat side of the half toward the perforated surface. As the drums turn, the avocado halves are carried to the press drum and the meat from each half is pressed through the perforated drum. The retaining plates on either side of the drums prevent the avocado halves from falling from the drums. The doctor blade inside the perforated drum cuts the meat from the peel at the contact area where the press drum exerts the greatest pressure on the avocado. The meat moves down the shoot from the inside doctor blade out of the perforated drum and drops into a container. The peels of the avocados are removed from the perforated

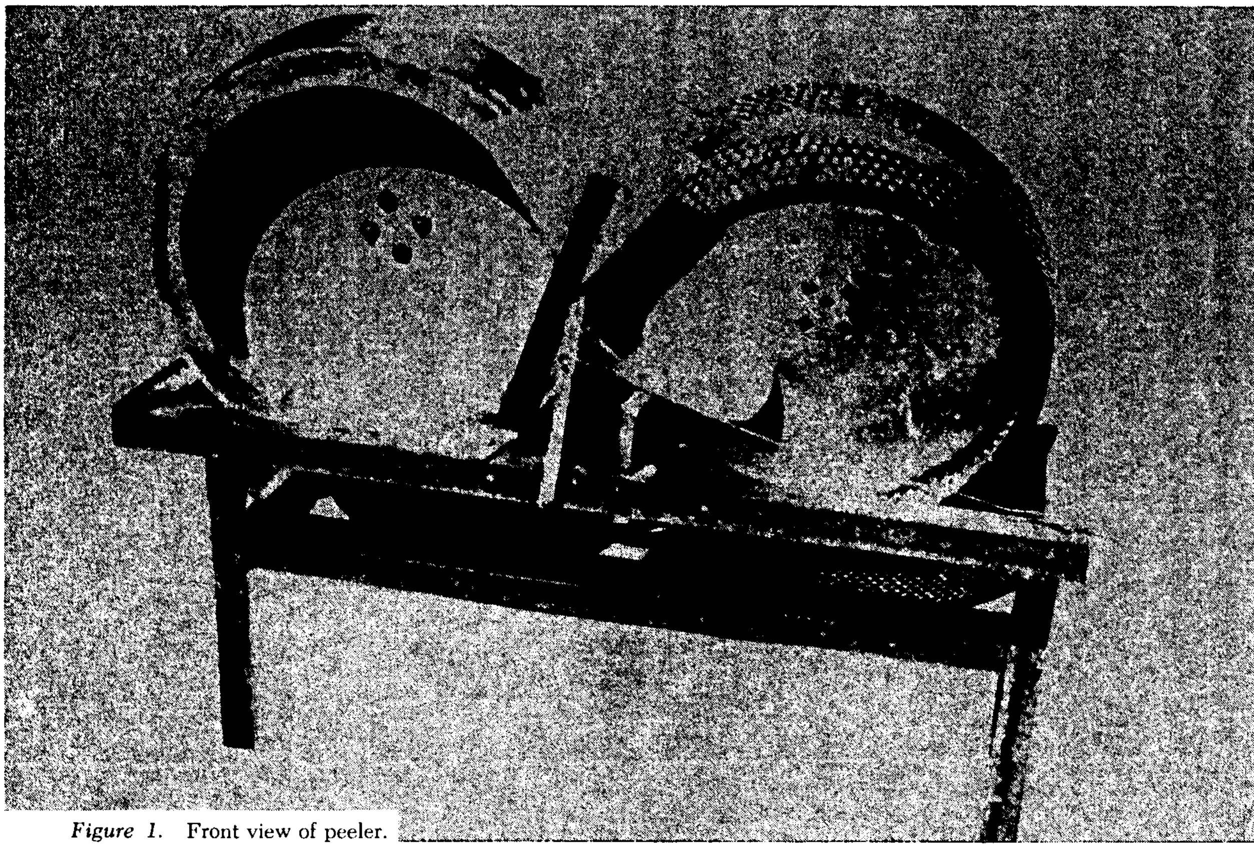

Figure 1. Front view of peeler.

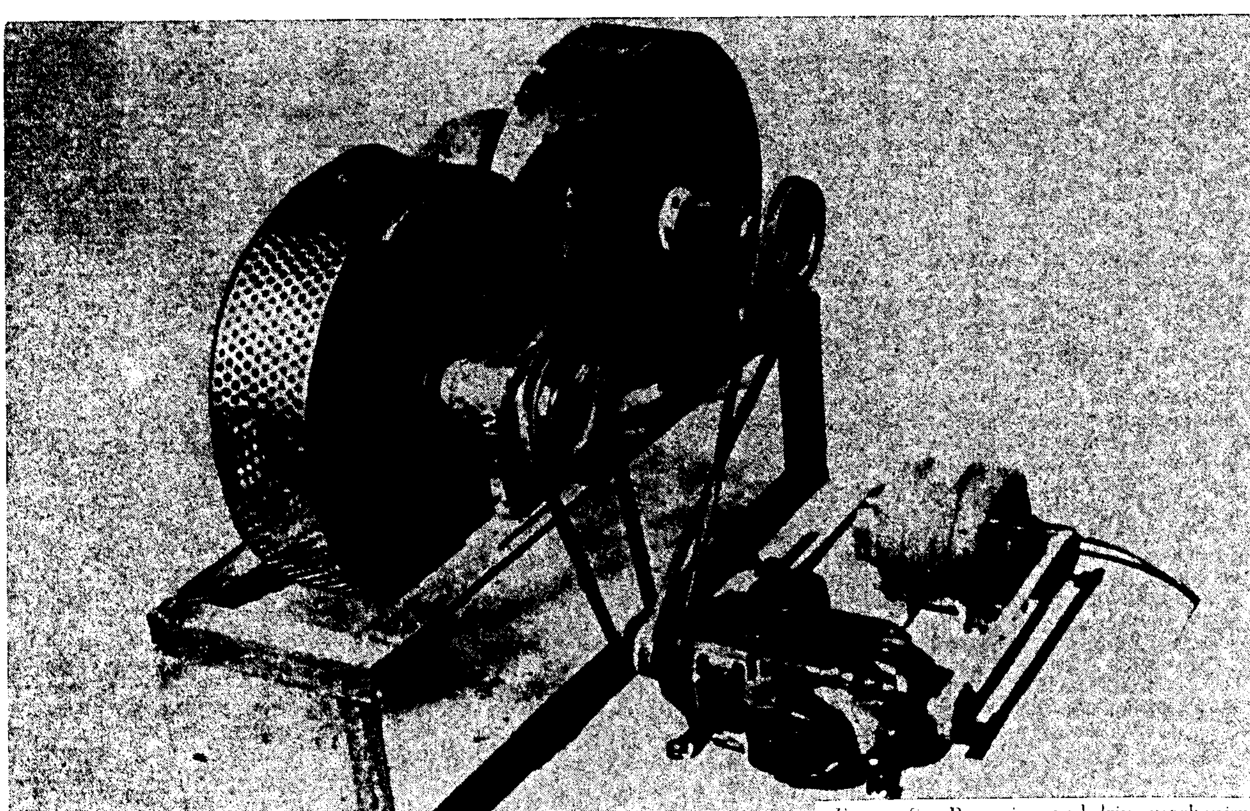

Figure 2. Rear view and drive mechanism.

drum by the outside doctor blade and drop into a second container.

Some avocado meat remains on the peel, as shown in Figure 3. The amount remaining on the peel is determined by the thickness of the metal used to construct the surface of the perforated drum. Numerous batches of avocado halves were peeled with the machine. The percentage of meat remaining on the peel of two 4540 gram batches are presented in Table 1 to show the capability of this machine. The meat remaining on the peel was carefully scraped from the processed peel and the percentage meat remaining on the peel calculated. The 8.4 and the 6.2 percent for the two batches represents that part of the avocado meat which the machine does not remove and will be discarded with the peel. The percentage of peel and meat of the fruit halves discarded by this operation is 24.5 percent for the first batch and 23.8 percent for the second batch. Stephens, (5), reported a 21 percent loss when the same variety was peeled by hand.

There are a few precautions which should be considered in the event a similar machine is constructed. The round holes in the perforated drums should be beveled on the side next to the avocado meat to allow the peel to slide over the surface of the perforated drum as the avocado half is flattened by the press drum. The suface of the perforated drum should be constructed of thin metal to reduce the quantity of meat which may remain on the peel. The drums should be at least 16 inches in diameter or larger so the angle at the nip will not be too abrupt. If the drums are too small the avocado halves slip and will not be forced between the drums. The press drum should be mounted on a hinged plate held under spring tension so it can move away from the perforated drum to prevent green halves or seed which might accidentally be placed in the machine from damaging the perforated drum. The use of heavier bearings than bicycle hubs is recommended.

ACKNOWLEDGEMENT

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Figure 3. The peel as it is removed from the machine.

Table 1. Percent meat removed and the percent remaining on the peel of Lulu variety avocados.

Wt. of avocado halves	*Wt. of meat recovered*	*Meat recovered*	*Wt. of peel from machine*	*Wt. of avocado meat scraped from processed peel*	*Wt. of hand cleaned peel*	*Hand cleaned peel*	*Meat which remains on peel and is lost*
gms	*gms*	%	*gms*	*gms*	*gms*	%	%
4540	3430	75.5	1110	380	730	16.1	8.4
4540	3458	76.2	1082	281	801	17.6	6.2

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