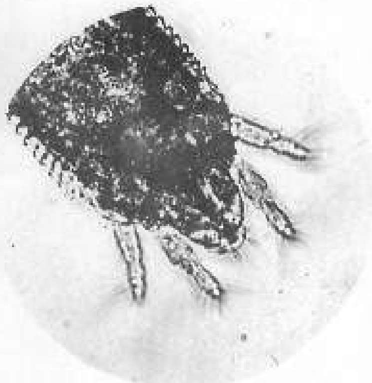

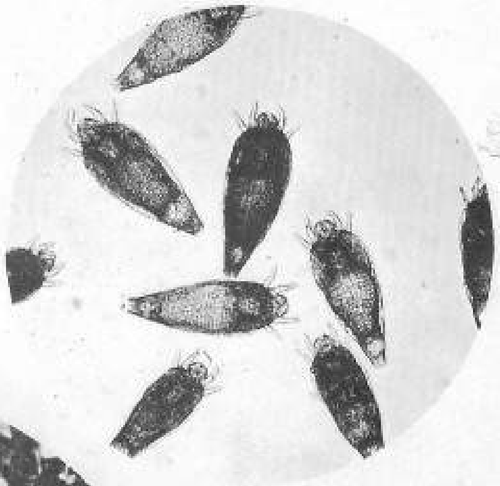

JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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Aims and Objectives of the Society

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

At regular meetings, subjects of interest are presented by specialists in their field. These presentations are followed by open forums. The *Newsletter* announces and discusses these programs and brings other news of interest to Society members.

The Society has sponsored 30 annual Institutes featuring outstanding speakers from all parts of the country who have presented new developments in the field of horticulture. Panel discussions, social get-togethers, and a barbecue complete the all-day program.

Talks given at the Institute and reports of Valley research are published in the *Journal of the Rio Grande Valley Horticultural Society*, providing a continuing record of horticultural progress in the Valley.

Anyone interested in horticulture can become a member of the Society. The annual fee is $5.00, which includes a subscription to the *Journal*. Applications for membership, and annual dues should be sent to the Secretary-Treasurer, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas 78596.

Mr. Andy Scott, Jr.
President

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Horticultural Society
1977

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Recipient of the
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1976

Mr. Rumaldo T. "Mayo" Correa is a native of San Perlita in the Lower Rio Grande Valley. He was wounded in combat during the Normandy invasion of World War II. He received a B.S. degree in Agricultural Education in 1950 and a M.S. degree in Horticulture in 1953 at Texas A&M University. Since 1953, he has been employed by the Texas A&M University Agricultural Research and Extension Center at Weslaco, where he is presently a Professor of Horticulture.

Mr. Correa has received three other coveted awards: Texas Citrus and Vegetable Growers and Shippers Association plaque in 1967; Northrup King Seed Company "Honorary Feature" in 1970; and coincident with the Potts Award, the State Agricultural Experiment Station Centennial Award (a gold medallion) from the Texas A&M College of Agriculture.

Mr. Correa is known internationally for his success as a melon breeder, particularly for breeding disease resistance into the TAM-Dew honeydew and Perlita, Dulce, and TAM-Uvalde cantaloupes—Perlita alone has developed an industry in the Lower Rio Grande Valley with an average annual value of 7.5 million dollars. He has also developed and released the Rio Gray watermelon and the Tex-long slicer cucumber, and he has made major breeding contributions to many other fruits and vegetables.

During his distinguished career, Mr. Correa has served as a consultant on vegetable crops in many Latin-American countries; but actually, the entire world has benefited from his expertise.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY
PATRON AND SUSTAINING MEMBERSHIP, 1977

The Rio Grande Valley Horticultural Society gratefully acknowledges the support of its Patron and Sustaining Members for making the *Journal* publication possible and for their outstanding contributions to the Valley's horticultural industry.

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ADDRESS OF WELCOME

Thirty-first Annual Horticultural Institute
Dr. Ben Villalon
President
Rio Grande Valley Horticultural Society

It is indeed a pleasure to welcome everyone to the Thirty-First Annual Horticultural Institute. Today's program appears to be interesting; I am sure it will be informative. Our Institute Program Chairman, Mr. Ed Cox has done an excellent job, and we are complimented by the high quality of the speakers who have agreed to participate, particularly those who have traveled far. I am positive that this Institute will equal, if not exceed, the excellence of those in the past.

Many events, mostly good, have occurred in Valley agriculture, since the first Institute was held back in 1946.

Much work has been done and considerable progress has been made in the past 30 years, but many of the problems are yet far from being solved.

The purpose of the Society today is the same as it was 30 years ago. Let me briefly state the aims and objectives.

AIMS AND OBJECTIVES OF THE SOCIETY

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

At our regular monthly meetings, now limited to 2 in the Spring and 2 in the Fall, subjects of interest are presented by specialists in their field. These presentations are often followed by open forums. *The Newsletter* announces and discuss the monthly programs and brings other news to the interest to society members.

The Society has sponsored 30 annual Institutes such as this one, where outstanding speakers from all parts of the country present new developments in the field of horticulture. Panel discussions, social get-togethers, and noon-luncheon, and the evening ornamental session especially dedicated to the ladies rounds out the all-day program.

Talks given at the Institute and reports of Valley research are published in the *Journal* of the Society; this provides a continuing record of horticultural progress in the Valley. The *Journal,* I might add, has world-wide distribution.

Anyone interested in horticulture can become a member of the Society. The annual fee is still only $5.00 and includes the *Journal*. Our Secretary and Treasurer are ready to receive your application.

Your presence here today is indicative of your interest in some phase of horticulture. Through your attendance, you are contributing to the society's program in its efforts to promote Texas to be number one in horticulture.

It has been an honor and has given me great pleasure to have served as President for 1976.

Program of the Thirty-First Annual Institute
Rio Grande Valley Horticultural Society
January 25, 1977

MORNING SESSION: Paul L. Thompson—Presiding

Address of Welcome .... Dr. Ben Villalon
President,
RGV Horticultural Society

"Avocados in Texas: History,
Problems, and Future" .... Norman P. Maxwell
Associate Professor, Horticulture,
Texas Agricultural
Experiment Station,
Weslaco

"Citrus Marketing in South Texas" .... James S. Agar
Vice-President, Marketing,
Texas Citrus Exchange,
Edinburg

"Michigan Horticulture and
Horticultural Research at
Michigan State University" .... Dr. Shigemi Honma
Professor, Horticulture,
Michigan State University,
East Lansing

Presentation of the
Arthur T. Potts Award .... Dr. Ben Villalon
President

AFTERNOON SESSION: Paul W. Leeper—Presiding

"The Role of TAMU Horticultural
Sciences Department in
Texas Horticulture" .... Dr. Warren S. Barham
Head, Horticultural
Sciences Department,
Texas A&M University,
College Station

"Making Hot Peppers Sweet" .... Dr. Ben Villalon
Assistant Professor, Virology,
Texas Agricultural
Experiment Station,
Weslaco

"Drip Irrigation of Valley
Horticultural Crops" .... Dr. Calvin G. Lyons, Jr.
Area Horticulturist, Citrus,
Texas Agricultural
Extension Service,
Weslaco

EVENING SESSION: Dr. Ben Villalon—Presiding

"A Look at a Chrysanthemum
Show in Japan" .... Dr. Shigemi Honma
Professor, Horticulture,
Michigan State University,
East Lansing

"Spain As We Saw It" .... Dr. Richard A. Hensz
Director and Professor, Horticulture,
Texas A&I University,
Weslaco

ABSTRACT OF TALK PRESENTED AT THE 31ST ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Michigan Hortulture and Horticultural Research at Michigan State University

Shigemi Honma
Professor, Horticulture
Michigan State University
East Lansing, MI 48824

The state of Michigan surrounded on three sides by lakes makes it ideally suited for the growing of horticultural crops. Ninety-nine percent of the horticultural crops are grown in lower Michigan and are located between 32 to 46 degrees north latitude. This encompasses an area 195 miles wide and 275 miles long.

In 1975, Michigan's fruit and vegetable crops were worth approximately $161 million to the growers. Production varies from year to year and is greatly affected by spring temperature and rains which influences fruit pollination and may delay field operations in the growing of vegetables. Fruit growing is generally confined to the western third of the state while the vegetables were scattered with the largest percentage in the lower half of the state.

There are approximately 10,000 acres of nursery stock worth about $12 to 15 million and approximately 200 acres of greenhouse floriculture worth some $25 million. One-half of the greenhouse Horticulture is devoted to growing of bedding plants.

The major fruits grown are apples, tart cherry, sweet cherry, grapes, prunes and plums, pears, peaches, and strawberries (Table 1). Major vegetables grown are asparagus, snapbeans, cabbage, carrots, cauliflower, cucumbers, celery, sweet corn, onions, peppers, and tomatoes (Table 2). Most of the vegetables are grown on mineral soils; however, celery, carrots, onions, and head lettuce are grown on organic muck soil.

Research in the Horticulture Department in fruits includes the breeding of strawberries, blueberries, peach, nectarine, apricot, and cherry. Physiological studies include growth regulator, control of flowering, dormancy, nutrition, hardiness, scion relationship, weed control, and cultural practice for mechanical harvesting. Post-harvest physiology of fruits include growth, maturation, ripening, and storage of decidious fruits.

Table 1. Major fruits grown in Michigan in 1975.

Fruit	Acres	Fresh Market, %
Apples	53,500	35.0
Peaches	14,300	18.2
Pears	9,600	
Cherries, Tart	37,400	2.2
Cherries, Sweet	11,500	7.4
Prunes & Plums	7,400	30.0
Grapes	15,800	5.5
Blueberries	8,500	64.7
Strawberries	3,000	

Table 2. Major vegetables grown in Michigan in 1975.

Vegetables	Acres
Asparagus	17,800
Snapbean	15,200
Cabbage	4,500
Cantaloupe	2,100
Carrot	4,600
Cauliflower	750
Celery	2,100
Corn, Sweet	11,200
Cucumber	32,400
Lettuce	1,300
Onion	6,800
Pepper	2,000
Tomato	8,700

Research in floricultural includes breeding and genetics of floricultural plants, culture of bedding plants, bulb forcing, physiology of greenhouse flowers, and propagation and growth of woody ornamentals.

In vegetables, breeding and genetics include asparagus, snapbean, carrots, cauliflower, cucumber, lettuce, onion, pepper, and tomato. Physiological studies include growth regulator, studies to enhance production practices to facilitate mechanical harvesting, and weed control. Post-harvest research is on quality maintenance in storage and marketing of vegetables.

TALK PRESENTED AT THE 31ST ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY

AVOCADOS IN TEXAS, PAST, PRESENT, AND FUTURE

Norman P. Maxwell
Associate Professor, Texas Agricultural Experiment Station,
Weslaco, Texas 78596.

Avocados are not a new crop in Texas. The first trees were brought in from California in the 1930's. At this time it was thought avocados were not adapted to the Lower Rio Grande Valley.

California primarily uses the Mexican race avocado as rootstock. Characteristically this race translocates excessive amounts of chlorides from irrigation water into the foliage causing tipburn with premature dropping of the foliage, quite often causing a short-lived tree.

Dr. R. H. Cintron in the 1940's determined from the results of an avocado test plot on Hoblitzelle Ranch near Mercedes that the California avocado varieties commonly planted at that time were not well adapted to climatic conditions in the Valley. Several problems found were anthracnose on the fruit, poor fruit set, and improper ripening of the fruit.

In 1948, a group of Valley nurserymen, growers and research personnel from the USDA and the Texas Agricultural Experiment Station became interested in determining the possibility of home garden and commercial avocado production. This group formed the Texas Avocado Society which became part of the Rio Grande Valley Horticulture Society in 1954.

A committee was appointed to look at avocado trees currently growing in the Valley and determine if any of these cultivars would be promising for the area. Several trips were also made into Mexico looking for superior avocado trees. At this time, a 15-tree planting of Lula avocados was found on Kansas City road near La Feria. The trees were about 14 years old and reportedly bore good crops of fruit every year. The committee thought the variety showed a lot of promise for the Lower Rio Grande Valley.

Several test plots were planted in different areas of the Valley to test promising selections and varieties from Florida, California, Mexico, and the Valley.

The Texas Agricultural Experiment Station became actively involved in the avocado work in 1948 and has continued a limited research program up to the present.

This gives a short background on some of the previous avocado work showing that the present interest in growing avocados has considerable accumulated information.

Why are we interested in trying to establish an avocado industry in Texas?

1. There are only three areas in the continental United States where avocados can be grown successfully (Southern California, extreme South Florida, and the Lower Rio Grande Valley of Texas).

2. Avocados are not over planted (about 50,000 acres in the United States) and the market is still being developed. Calavo has been doing extensive advertising and market development during the past several years. Market development from California, Florida, or Texas should help avocado sales from all of the growing areas.

3. Texas cities are good market outlets for avocados. San Antonio, Dallas, and Houston are considered to be in the top 10 cities for sales of avocados in the United States.

4. The growing of avocados would give the Lower Rio Grande Valley another high value per acre fruit crop for diversification.

5. The Lower Rio Grande Valley has some growing cost advantages over competing areas. One advantage is land cost. Even though Valley land has increased in cost, it is still available at a lower price than in California or Florida.

   Both California and Florida are losing their prime avocado growing areas to real estate development. This forces a move to areas where avocado tree performance has not been adequately tested. Texas is also losing prime avocado land to real estate development, but there is still land available in the Valley that is suitable for growing avocados. A general criterion for land selection in the Valley is good internal and surface drainage of water. Good citrus land is also good avocado land.

What about freezes? Avocados are supposed to be cold tender. There is a wide range of cold tolerance between avocados depending upon race and variety within the race.

There are three races of avocados (West Indian, Guatemalan, and Mexican) and hybrids between the different races. The West Indian race is the most cold tender. Freeze damage to the tree generally occurs around 29° to 20°F. The Guatemalan race generally sustains freeze damage to the trees about 26° to 28°F. The most cold hardy of the races is the Mexican which will tolerate temperatures into the low 20's before cold damage occurs to a dormant tree. The cold tolerance of hybrids between the races or between cultivars within each race may vary and every cultivar has a slightly different threshold at which freeze damage will occur. Growing experience with a cultivar is needed before a temperature figure can be arrived at for the particular cultivar.

The only avocado variety that we presently believe has commercial potential for the Valley is the Lula variety from Florida. The Lula is a West Indian X Guatemalan hybrid, has green fruit (10 to 20 ounces), matures from October through February in Texas, and is very well adapted to the Lower Rio Grande Valley climatic conditions. The Lula tree sustains cold damage to the foliage at 17°F after 2 or 3 hr. As the temperature drops below this figure freeze damage will increase.

Citrus fruit also freezes at 27°F after 4 hr. In those areas where we can grow citrus for fruit production through the winter, we should also be able to grow the Lula avocado.

In most areas of the Valley we seldom get temperatures of 27°F or below. At Weslaco the occurrence is about 1 out of 3 years but this is not evenly spaced. Weather records show long periods of up to 10 years between 27°F temperatures and then periods when it occurred in two or three consecutive years. Lower temperatures than 27°F also occur in the Valley such as happened during the major freezes of 1949, 1951, and 1962.

Avocados have an advantage over citrus. A young or mature avocado tree can be frozen to the ground, but it will be back in limited production generally 1 year after being frozen if the bud union is protected allowing the tree to regrow from above the graft union. Mature trees will make 6 to 10 ft of regrowth during the first growing season.

A mature citrus tree frozen to the ground does not have the recuperative ability to quickly regrow a top and make a good yielding tree again. Citrus trees damaged to this extent must be removed and the grove replanted.

Since the ground doesn't freeze in the Valley and avocados are not susceptible to foot rot, the bud union can be protected by burying it 1 or 2 inches deep at planting time, and after about the second year, a permanent soil bank can also be placed around the trunk.

Several small plantings of avocados established from 1949 to 1960 have been frozen to the ground, but they had the bud unions protected. The trees regrew the tops and have made good commercial trees.

The Lula avocado will start producing commercial crops about the fourth year. Production on experimental trees has averaged 15 lb. the fourth year, 45 lb. the fifth year, and 97 lb. the sixth year. It is expected that mature tree production will be about 100 lb.

Gross returns on a mature grove at 30 cents/lb. for fruit should be about 2,000 to 3,000 dollars/acre. Grove care costs per acre (about $420.00) on a mature grove are estimated by the Texas Agricultural Extension Service to be slightly less than for citrus (about $500.00).

Up to this time insects and diseases have not been a problem on Lula avocados. This situation could change, but no spray programs have been needed for insect and disease control.

As to the planted acreage of Lula avocados in the Valley, about 500 acres of Lula avocados are estimated as being planted at the present time with additional acreage being added each year.

The Texas Agricultural Experiment Station has conducted a limited avocado research program since 1948. Currently research is underway with the following categories:

1. Varieties adaptable to the Lower Rio Grande Valley

2. Performance of Lula avocado trees under drip irrigation

3. Performance of Lula avocado trees under flood irrigation

4. Effect of harvest date of Lula avocados on next year's yield and cumulative effect over several seasons

5. Avocado rootstock tests

6. Anthracnose control on Mexican race avocados

7. Propagation of nursery trees

Another area that should be mentioned is problems for Texas avocado production. Some of the more important ones are listed below:

1. Tree establishment

An avocado grove requires more supervision during the first 2 years after planting than a citrus grove. Irrigation on time, weed control, sun and wind protection for the trees are critical areas that must be properly managed to hold young avocado trees losses to a minimum. During the first growing season, depending upon management, tree losses can range from as low as 2% up to 50%. An avocado grove cannot be absorbed into a citrus grove care operation and be managed as another citrus grove. At the end of the second growing season, avocado trees are generally well established and care problems become less.

Some other problems a grower must watch for during the establishment period are termite damage, grub worm damage to the root systems, and iron chlorosis. All the these problems have solutions, but a grower should be aware that they can occur.

2. Cold protection

Freeze protection for young trees can be accomplished by burying the bud union 1 to 2 inches deep at planting time (avocados are not susceptible to foot rot). The trunk can also be banked with soil. The bank should be removed in March while the bark is still green and subject to damage from wet soil around it. About the second year when the bark on the trunk is more mature, a permanent soil bank can be made and not removed.

Foliage damage from cold can be expected to occur on mature Lula trees at 27°F. The gross income from an acre of Lula avocados is high enough that it is economical to provide some form of cold protection. Again, as with young trees, a permanent soil bank around the trunk will protect the graft union in case temperatures are too cold for the cold protection system to work efficiently.

3. Nursery tree propagation

Grafting techniques need to be improved so that grafting can be done the-year-around with 80% or better success. Currently the number of unions that grow is 90% or better from November through February. The percentage of successful graft unions drops rapidly as hot weather increases in the spring and early summer months. It is thought that by modification of the microclimate around the grafts, a higher percentage of successful unions can be made during hot weather.

4. Anthracnose disease control on Mexican race avocados

If a practical control can be found for anthracnose disease on Mexican race avocados, the avocado shipping season could be lengthened (July through February), more cold hardy varieties could be grown, and additional areas of South Texas would be adaptable for growing avocados. The Texas Agricultural Experiment Station is testing fungicide sprays and searching for tolerance to anthracnose within the Mexican X West Indian hybrids that might have fruit peel thick enough to prevent anthracnose from infecting it. Anthracnose is only a problem on thin-skinned Mexican race avocados.

5. Fruit theft (finger blight)

Wherever avocados are grown, California, Florida, or Texas, theft of fruit is a problem. A grower should be aware of the problem and try to protect his grove against theft. The most practical solution, at this time, is fencing.

6. Marketing

A possible problem could be orderly marketing of the fruit. At present, the gift fruit industry and local sales have taken most of the available avocados, but probably starting this year there will be more fruit than the gift and local sales can handle. Commercial shipments will have to start this fall, and in turn, problems could arise in grower sales, sufficient shippers, proper handling in packing houses and markets to receive the fruit.

The future looks good for avocado culture in the Lower Rio Grande Valley. Avocados won't replace citrus, but they are an alternative high value/acre crop for diversification. There are about 500 acres presently planted in the Valley. We believe this could increase to 2,000 acres within the next 10 years and continue expanding as the market is better developed in the United States.

RESEARCH REPORTS

Evaluation of PP 199 and ZR 856 for Rust Mite Control on Texas Citrus

J. Victor French, and Reed J. Reeve
Assoc. Prof. and Research Assoc.
Texas A&I University Citrus Center
Weslaco, TX 78596.

ABSTRACT

Promising results were obtained with two new experimental acaricides, PP 199 and ZR 856, in efficacy trials against citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) on grapefruit. In preliminary trials during 1975, ZR 856 at 0.21 and 0.42 lb ai/100 gal provided effective rust mite control for 12 weeks, and PP 199 at 0.17 lb ai/100 gal was effective through 10 weeks post spray. PP 199 at 0.08 lb ai/100 gal and the standard acaricide, chlorobenzilate (0.25 lb ai/100 gal) lost efficacy by 6 weeks. Full season trials with ZR 856 and PP 199 were conducted in 1976. A 28 April application of ZR 856 (2 lb ai/acre) by commercial sprayer on a 2-acre-block of "Webb Redblush" grapefruit significantly reduced rust mite populations, but economic control was not obtained until a 14 June spray. In a second block of grapefruit applications on 6 May and 27 July of PP 199, at rates of 0.06, 0.13 and 0.18 lb ai/100 gal, all provided season-long rust mite control. No phytotoxicity was observed following any treatment applications of ZR 856 or PP 199.

Unusually heavy populations of citrus rust mite *Phyllocoptruta oleivora* (Ashmead), were encountered in many citrus orchards in the Lower Rio Grande Valley during the 1975-76 and 1976-77 seasons. Growers, particularly in the western sections of the Valley, found it necessary to add from 1-2 extra acaricidal sprays to their regular seasonal rust mite control programs. Even with additional sprays, it was often difficult to establish effective control and great numbers of rust mite damaged fruit were found at harvest.

At present there are no adequate biological controls for citrus rust mite and growers must rely on chemical control measures. Because certain of the acaricides currently registered for Texas citrus have complicating factors that limit their use, continued effort is needed to find and test new and potentially more effective materials (1).

This paper presents results of orchard trials conducted over two seasons with two new experimental acaricides, PP 199 (ICI United States Inc., Goldsboro, N.C.) and ZR 856 or Zardex® (Zorcon Corp., Palo Alto, Calif.).

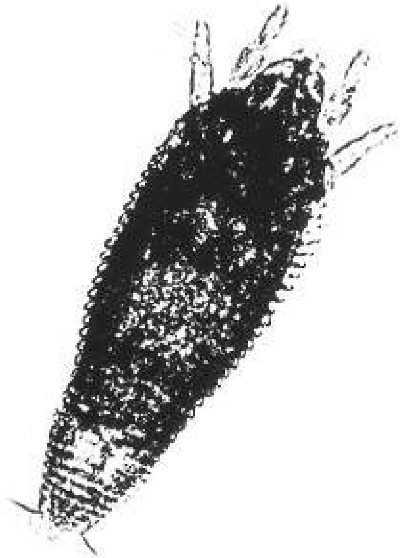

Fig. 1. Citrus rust mite, *Phyllocoptruta oleivora* (Ashmead). 540X.

MATERIALS AND METHODS

Chemistry Formulations — PP 199, 22% colloidal suspension (flowable), N-[2-Chloro-5-(trifluoromethyl)phenyl]-2, 4-dinitro-6-(trifluoromethyl) benzenamine; ZR 856, 40% wettable powder, Hexadeycl cyclopropanecarboxylate.

Standard acaricides used in these trials were chlorobenzilate (Acaraben® 4E) Ethyl 4,4-dichlorobenzilate and dicofol (Kelthane® MF) 1, 1-Bis(Chlorophenyl)-2, 2,2-trichloroethanol.

Application of Test Acaricides — Small plot trials (< 10 trees/treatment) were sprayed by handgun from either a John Bean Model 1010-MBTB Sprayer, (FMC Corp., Jonesboro, Ark.) at 250 psi, or a Hardie Hydraulic Sprayer at 550 psi. Acaricides were normally formulated in tank mixes of 100 gal with no surfactants or sticking agents. Trees were sprayed to runoff ca. 20 gal/tree.

Test plots with 10 or more trees were sprayed by a John Bean Model F-357 CP Speed Sprayer (FMC Corp. Jonesboro, Ark.). Pressure, nozzling and speed of sprayer was regulated to apply 250 gal spray/acre, with ca. two thirds of the spray volume directed at the top one-third of the trees. All testing was done on the research farms of Texas A&I University Citrus Center.

Mite Counts and Fruit Damage Evaluations — Efficacy of test acaricides was determined from rust mite counts (pre- and post-treatment) on leaf samples from test trees. Sample size and test plot design varied with individual trials and are described under the acaricide tested. Leaves were examined for mites in the laboratory under a binocular microscope. Percent infestation and/or relative rust mite density were determined, and a sample was considered infested if any living mites were counted. Density of live rust mite was rated on the following scale: 0.0 = no mites; 1.0 = 1-5; 2.0 = 6-10; and 3.0 = >10 mites/leaf. In these trials a mite density of 1.0 - 1.5/leaf was considered as the economic threshold, and at which level an acaricidal spray is normally recommended.

When season long trials were conducted a rust mite damage evaluation of the fruit was made at harvest. Fruit was rated for severity of damage using grading categories as outlined in "United States Standards for Grades of Grapefruit" (3). Fruit sampling procedure and sample size are described under the individual acaricide test.

Preliminary Trials with PP 199 and ZR 856 — Short term trials with both experimental acaricides were conducted in 1975. Separate blocks of 20-year-old "Webb Redblush" grapefruit trees were used; with PP 199, at 0.08 and 0.17 lb ai/100 gal applied in one block; and ZR 856, at 0.21 and 0.42 lb ai/100 gal applied in the second. The standard acaricide in each test was chlorobenzilate at 0.25 lb ai/100 gal. Applications were made on 20 May by Hardie handgun, with each treatment replicated on 3-5 trees.

Full Season Trials with ZR 856 — In 1976, ZR 856 was applied by commercial sprayer to a 2-acre-block of mature "Webb Redblush" grapefruit trees. Initial application of ZR 856 (at 2 lb ai/acre) was on 28 April, with reapplications on 14 June and 30 July. A single row of 20 trees received applications of chlorobenzilate (1.5 lb ai/acre) on the same dates; and a second row of 20 trees was left as an unsprayed control. Rust mite counts were made at 2-4 week intervals throughout the season, with the terminal count 12 weeks after the 30 July application. At harvest on 23 Nov a random sample of 25 fruit was taken from each of 20 trees in the ZR 856 treatment, and from 10 trees in both the chlorobenzilate & control treatments. These fruit were evaluated for rust mite damage.

1976 Trials with PP 199 — Testing of PP 199 was expanded to full season trials in 1976. PP 199 at 0.06, 0.13 and 0.18 lbs ai/100 gal was compared to the acaricide standard, dicofol at 0.50 lb ai/100 gal. Treatments were completely randomized and each treatment replicated 4 times in single-tree plots on 20-year-old "Webb Redblush" grapefruit trees. Treatments were applied initially on 6 May and re-applied on 27 July, using the John Bean Model 1010 MBTB sprayer. Mite counts were made at 4-week-intervals, with the final count on 18 Oct, or 12 weeks after the 27 July spray. Fruit quality evaluations were made 30 Nov, with 100 fruit randomly sampled from each treatment and assessed for rust mite damage

RESULTS

Preliminary Trials — Both rates of ZR 856 (0.21 and 0.42 lb) provided effective rust mite control through 12 weeks (Fig. 2). PP 199, at 0.17 lb was effective through 10 weeks posttreatment (Fig. 3). The 0.08 lb rate of PP 199 and chlorobenzilate, the standard acaricide used in both test blocks, lost efficacy by 6 weeks posttreatment. No phytotoxicity was observed in trees sprayed with any of the treatments.

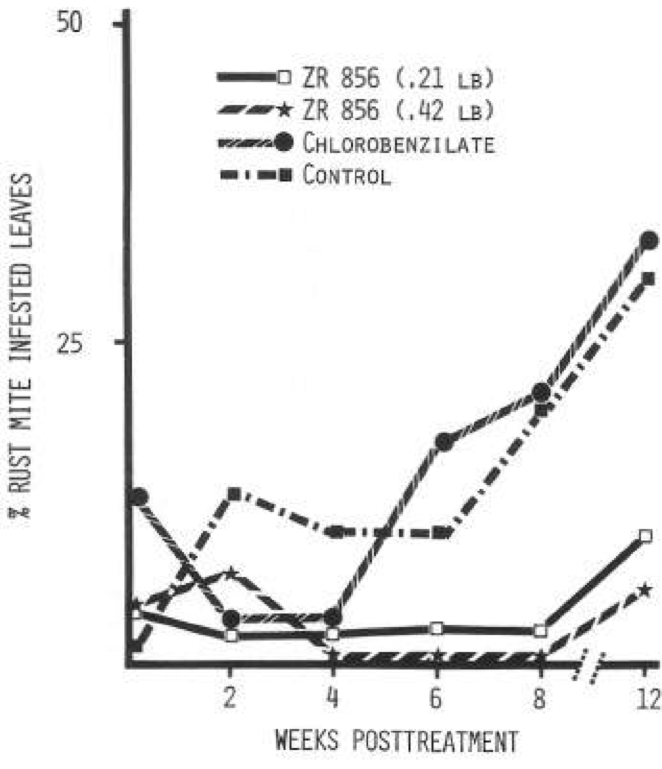

Fig. 2. Comparison of posttreatment rust mite populations on grapefruit trees sprayed with the acaricides, ZR 856 or chlorobenzilate.

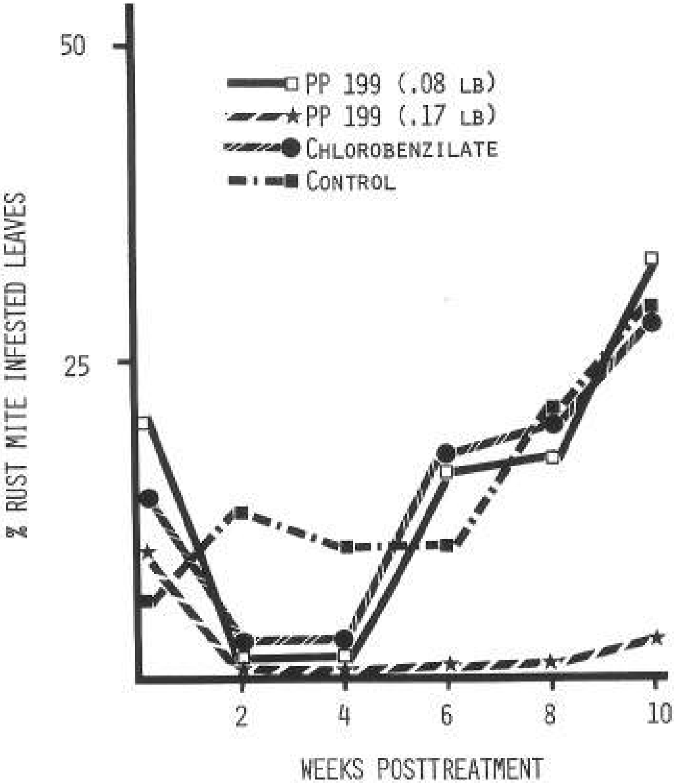

Fig. 3. Comparison of posttreatment rust mite populations on grapefruit trees sprayed with the acaricides, PP 199 or chlorobenzilate.

ZR 856 Trials, 1976 — The test block received nearly 2 inches of rainfall about 48 hours after the 28 April application was made; and while both the ZR 856 and the chlorobenzilate treatments significantly reduced rust mite populations (*versus* the unsprayed control), economic control was not established until the 14 June spray (Table 1). Following the 30 July spray, ZR 856 effectively controlled rust mite for 12 weeks posttreatment.

A total of 26 inches of rain was recorded in the test block during the period of these trials, ca. 13 inches prior to the 30 July spray and 13 inches thereafter.

Data from rust mite damage evaluations at harvest are given in Table 2. About the same percentage of US #1 fresh fruit was harvested from the ZR 856 and chlorobenzilate treatments, 67% **versus** 69%, respectively. Damage in the unsprayed control was so severe that 84% of the sampled fruit were packinghouse eliminations, usable for juice only.

Table 1. Density of live citrus rust mite on "Webb Redblush" grapefruit trees receiving 3 applications of ZR 856 (vs. standard acaricide, chlorobenzilate) during 1976.

		Rust Mite Density[1]									
			1st Spray 4/28			2nd Spray 6/14		3rd Spray 7/30			
Treatment	lb ai/A	-1[2]	+ 1[3]	+ 4	+ 6	+ 3	+ 6	+ 2	+ 4	+ 8	+ 12
ZR 856	2.0	2.2a	1.5b[4]	0.7b	0.8b	0.5b	0.6b	0.2b	0.0b	1.0b	0.1b
Chlorobenzilate	1.5	2.0a	0.8b	0.7b	1.5b	0.4b	0.7b	0.0b	0.1b	0.2b	0.0b
Control	---	2.0a	2.3a	1.2a	2.2a	2.7a	2.4a	0.8a	0.8a	1.5a	0.6a

[1] Average number of mites per leaf based on the following density rating: 0.0 = no mites; 1.0 = 1-5; 2.0 = 6-10; 3.0 = > 10 mites/ leaf.

[2] Pretreatment count.

[3] Weeks Posttreatment.

[4] Treatments followed by the same letter are not significantly different according to Duncan's Multiple Range Test, P. = 0.05.

Table 2. Citrus rust mite damage evaluation at harvest of grapefruit sampled from ZR 856 treated (vs. chlorobenzilate treated) trees.

Treatment	Rate	Percent Fruit by Grades[1]: U.S. #1	U.S. #2	Juice
ZR 856	2.0[2]	67(%)	15	18
Chlorobenzilate	1.5	69	12	19
Control	---	7	9	84

1 Fruit evaluated for rust mite damage using the following grade categories: free and mild = U.S. #1; moderate = U.S. #2; severe = useable for juice only.

2 lb ai per acre (250 gal).

PP 199 Trials, 1976 — Following the 6 May application all rates of PP 199 controlled citrus rust mite through 8 weeks posttreatment (Table 3). After the 27 July application the 0.06 lb treatment of PP 199 lost efficacy between the 8- and 12-week-counts, while PP 199 at 0.13 and 0.18 lbs and the dicofol treatments were still effective at 12 weeks. No phytotoxicity was observed following any of the treatment applications.

Rainfall recorded in the test block between May 6 and July 27 was 11.4 inches and between July 27 and Oct 27 was 9.8 inches.

All PP 199 treatments yielded exceptionally high percentages of US #1 fruit at harvest, > 90% *versus* 87% and 23%, for the dicofol and unsprayed control treatments, respectively (Table 4).

DISCUSSION

Citrus rust mite are traditionally more of a problem in orchards in the eastern part of the Valley nearer the Gulf, due primarily to the higher humidity and somewhat cooler temperatures prevailing in this area (2). However, in the past two seasons (1975/76 and 1976/77) while rust mite infestations have risen sharply Valleywide, the most significant increases have been in orchards in the western Valley. Several factors undoubtedly contributed to the dramatic population increases and difficulties encountered by growers in attaining control:

1) Near optimal climatic conditions prevailed for rust mite life-stage-development, with above normal rainfall (some localities exceeded 30 inches for 2 successive seasons). Moreover, winters were cool and without freezes, which permitted incipient rust mite infestations to persist in orchards during the December-March period.

2) Many growers applied the first or post bloom spray too late in the spring, or after fairly heavy rust mite populations were already established in orchards.

Table 3. Density of live citrus rust mite on "Webb Redblush" grapefruit trees receiving 2 applications of PP 199 (vs. acaricide standard, dicofol) during the 1976 season.

		Rust Mite Density[1]					
			1st Spray 5/6		2nd Spray 7/27		
Treatment	lb ai/100 gal	- 1[2]	+ 4[3]	+ 8	+ 4	+ 8	+ 12
PP 199	0.06	1.0a	0.1b[4]	0.0b	0.0b	0.4b	1.2a
PP 199	0.13	1.2a	0.0b	0.1b	0.0b	0.0b	0.3b
PP 199	0.18	0.8a	0.0b	0.0b	0.0b	0.0b	0.0b
Dicofol	0.50	1.0a	0.0b	0.2b	0.0b	0.0b	0.0b
Control	----	1.2a	1.8a	1.0a	0.8a	1.4a	1.2a

[1] Average number of mites per leaf based on a density rating scale of: 0.0 = no mites; 1.0 = 1-5; 2.0 = 6-10; 3.0 = > 10 mites/leaf.

[2] Pretreatment count.

[3] Weeks posttreatment.

[4] Treatments followed by the same letter are not significantly different according to Duncan's Multiple Range Test, P = 0.05.

Table 4. Citrus rust mite damage evaluation at harvest on grapefruit sampled from PP 199 treated (vs. dicofol treated) trees.

Treatment	Rate	Percent Fruit by Grades[1]: U.S. #1	U.S. #2	Juice
PP 199	0.06[2]	92(%)	7	1
PP 199	0.13	97	3	0
PP 199	0.18	98	2	0
Dicofol	0.50	87	8	5
Untreated Control	----	23	28	49

[1] Fruit evaluated for rust mite damage at harvest using the following grade categories: free and mild = U.S. #1; moderate = U.S. #2; severe = usable for juice only.

[2] lb ai per 100 gal.

Effective control was never attained in some orchards because subsequent sprays were ill-timed or poorly implemented.

3) Establishment of effective rust mite control can be seriously handicapped by frequent and heavy rainfall. Not only is it difficult to get spray equipment into water-logged orchards, but acaricidal sprays that are applied may be washed from the fruit and foliage, and provide little residual control.

4) In a limited number of cases an acaricide simply failed to provide control; a possible indication of tank mix incompatibility or development of rust mite resistence to certain of these materials.

In the current trials both ZR 856 and PP 199 performed well against moderate to heavy rust mite infestations, and under conditions of high rainfall. However, in 1976 the 26 inches of rain recorded in the ZR 856 test block and the 21 inches in the PP 199 test block was distributed throughout the duration of trials. On only one occasion was a spray application closely followed by heavy rains. The initial application of ZR 856 was followed within 48 hours by 2 inches of rain. This undoubtedly affected the performance of ZR 856 in 1976, and economic control of rust mite was not obtained until a second spray 6 weeks later. Moreover, early season rust mite damage was recorded on the fruit in this test plot, which ultimately resulted in a lower percentage of US #1 fresh fruit at harvest.

Results of the present trials indicate that ZR 856 and PP 199 could be valuable alternatives to those acaricides currently registered for use against citrus rust mite on Texas citrus. Further tests with both experimental materials are in progress.

ACKNOWLEDGEMENTS

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Citrus Mealybug: Populations in the Lower Rio Grande Valley of Texas

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ABSTRACT

Virgin female baited traps, visual inspection for infested fruit, and aerial photography with color infrared film were used to investigate the infestation of citrus mealybug, *Planococcus citri* (Risso), in grapefruit groves in the La Feria area of the Lower Rio Grande Valley in 1974-76. The trap catches showed three periods of major activity of males—May, August, and October. The visual survey showed that an average 58% of the trees in the groves were infested; aerial photography survey showed that approximately 80% of the grapefruit trees were infested.

The citrus mealybug, *Planococcus citri* (Risso), a serious pest of citrus, causes serious losses to growers in California, Florida, and several foreign countries (2, 3, 7). However, the pest is amenable to biological control, and releases of parasites and predators that are coordinated with application of selective chemicals and with good cultural practices have resulted in control in the areas where the mealybug was a major pest.

Until recently, the citrus mealybug was only a minor pest of citrus in Texas: occasional outbreaks occurred in isolated groves in parts of the Valley. Then in 1970, there was a serious outbreak on grapefruit on approximately 350 acres in the La Feria area of south Texas (1), possibly due to repeated use of certain broad spectrum phosphate pesticides (1). Since 1970 the number of grapefruit groves in the La Feria area damaged by the citrus mealybug has increased several fold. We therefore began a study of the mealybug population in the area in 1974.

MATERIALS AND METHODS

In 1974 and 1975, single sex pheromone traps, similar to the trap described by Rice and Moreno (6) and modified by Moreno (5), were placed in each of 40 - 50 grapefruit groves near La Feria; in 1976, five traps were placed in each of 17 groves, one in each corner and one trap in the center. New traps were set out every 1-2 weeks, and the exposed traps were returned to the laboratory where the number of male citrus mealybugs per 3 x 5 in. card was determined.

Hart et al. (4) had demonstrated that aerial photography with infrared color film could be used to detect infestations of the citrus mealybug. Therefore, in

November 1975, the citrus-growing area around La Feria was photographed at an altitude of 10,000 ft. with a modified K-37 camera with a 12-inch focal length lens and Kodak® color infrared film type 2443 (9.5 x 9.5-inch) format. (Company and trade names are included for the benefit of the reader and do not imply an endorsement of or preference for the product listed by the U.S. Department of Agriculture.) The boundaries of the study were: North - FM 107; South - Arroyo Colorado; East - Dilworth Road; and West - Cameron-Hidalgo County Line. After the transparencies were developed, they were examined on light tables. A microscope was used to closely examine each grove, and a rating was given to each grove for the percentage of trees showing the sooty mold characteristic of citrus mealybug infestations. A total of 213 grapefruit groves were examined by this method.

Finally, during a 2-week period in November 1975, a ground survey was made in the same 213 groves examined by aerial photography to determine the percentage of fruit infested with citrus mealybug. Each grove was checked by two people. Each person walked a circle through one-half of the grove and examined 50 fruit for citrus mealybug forms or sooty mold caused by citrus mealybug. Only one grapefruit per tree was examined.

RESULTS AND DISCUSSION

During 1974-1976, eight groves contained traps in all three years (Fig. 1). In 1974 and 1975, there were three peaks of male mealybug activity, one being in April-May, another in August, and a third in October-November. In 1976, the first two peaks occurred as previously, but there was no third peak, which was believed due to the cool early fall. Normally three generations of the citrus mealybug occur each year in the study area.

From the aerial photography and ground survey, we found that citrus mealybug damage was heavy in some groves over a 14-mile^2 area. Ratings made on the basis of aerial photography yielded an average 80% of the grapefruit trees infested with citrus mealybug. Ratings made on the basis of ground survey showed that an average of 58% of the trees were infested.

The data obtained from traps, aerial photography, and ground survey all showed the overall seriousness of the citrus mealybug problem in the La Feria area. This pest has spread considerably since 1970, and the amount of fruit damaged in some groves is very high. Insecticides are ineffective against established infestations of this pest, especially after the early season when the mealybug forms are protected by a heavy buildup of sooty mold on the fruit and leaves. A carefully coordinated integrated control program offers the most effective of dealing with the citrus mealybug problem in Texas.

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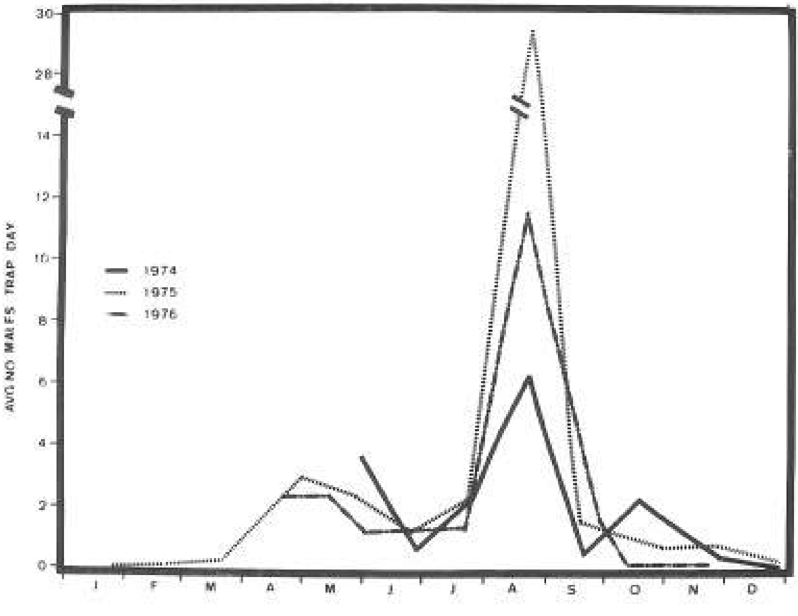

Fig. 1. Numbers of male citrus mealybugs captured on virgin female baited traps in eight grapefruit groves during 1974-76.

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Pest Management Considerations of the Effects of Pesticides on Texas Citrus Pests and Certain Parasites

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ABSTRACT

A complex of potential pests were found to occur on Texas citrus. Many times, the disruption of the pest to prey relationship of other potential pests was more important than the effect of the pesticide on the target pest. If the most effective and economical citrus pest management programs are developed, consideration must be given to the entire pest complex and the effects of pesticides against all potential pests and the agents exerting biological control.

Many Texas citrus growers plan their pest control program on the reported performance of one or two specific pesticides against the major pests. Other growers may use a combination of two to four pesticides which he feels assures he will not develop serious pest problems. During the last 10 years, many growers who applied the greatest amounts of pesticides have had more pest problems and a more difficult citrus pest complex to control. In many of these cases, secondary pests have become major pests which were more difficult to control than those originally under consideration. Such problems are caused by providing an environment more suitable for the target species and/or other potential pests to become more troublesome. Such an approach to citrus pest management is obviously poorly founded.

Development of a valid citrus pest management program requires consideration not only of the effect of various pesticides against the target pest and its beneficials, but also other potential pests and their beneficials. The development rate of the various pests and their beneficials, as well as the possible role of weather on the whole pest and beneficial arthropod complex, should be known. Pest management is more than just the utilization of one pesticide, although this might be valid if the target pests are satisfactorily controlled and other potential pests are economically controlled by their beneficials. One grower might use a particular control program with success while another may find it inadequate for many reasons. It is important that growers utilize all available knowledge if maximum utilization of beneficials and selectivity of pesticides are to result in minimum usage of pesticides and minimum environmental pollution.

It is our purpose to provide brief summaries of published and unpublished data that may be useful in development of the most valid approach to citrus pest management in Texas. Reference should be made to Table 1 when applicable from the discussion for definitive effects of the various pesticides against the various insects and mites and certain parasites.

Common names of insects and mites (1) acceptable to the Entomological Society of America are used throughout. The common usage names of pesticides are used, but where they differ from the acceptable common names by Entomological Society of America (2), they are shown in parenthesis as follows: Acaraben (chlorobenzilate), Kelthane® (dicofol), Vendex ® (Shell SD-14114), Trithion® (carbophenothion), Guthion® (azinphosmethyl), Carzol S.P. (formetanate hydrochloride), Supracide (methidathion) Cygon® dimethoate (dimethoate), and Sevin (carbaryl).

Citrus Rust Mite — This pest still prevails as the number one pest of Texas citrus, and the pesticides used for control may well determine the extent to which additional pesticides are employed for the control of other potential pests. Acaraben is being used more than any other pesticide for control, and no evidence has been reported to show that this pesticide produces significant kill of important beneficial insects. However, our evidence shows an apparent reduction in kill of rust mites when copper is added. Kelthane is used to some degree for control, but the senior author has encountered a single occurrence where barnacle scale increased to economic numbers when Kelthane was the only pesticide used in a citrus pest management program (with beneficial insects providing economic control of other pests). It was interesting that citrus rust mites were adequately controlled with Kelthane even though copper and foliar feed materials were added. Zineb has been successfully used for many years for control, of rust mites, but has not been used recently because of its slow action in control of dense citrus rust mite populations (17) and its detrimental effect on the beneficial citrus rust mite fungus, *Hirsutella thompsonii* (Fisher) (21,22). Ethion was used to a great extent with success in past years. Certain pest complications have been related to ethion usage, but control of citrus rust mites has been very effective when good coverage is attained. Vendex has given very effective control when adequate coverage has been achieved and less control when inadequate coverage and small gallonages were used. Sulfur was used in dust form for many years with varying results, but with continued usage, armored scales became greater problems with a greater scale to beneficial insect ratio. Residual control was many times very short with a follow-up application being necessary for control of mites hatching a few days after application. Trithion has had limited usage because of certain restrictive limitations in time of use although satisfactory control has resulted with good coverage. Control with Guthion has the shortest residual control of any pesticide suggested for use (6). Carzol S.P. has provided good control, but increases in certain armored scales occurred following applications.

Coverage has been a limiting factor in the pesticidal control of this very small pest. Control with 8 to 10 gpa by airplane application has varied from poor to

Table 1. Effects of various pesticides against certain Texas citrus pests and parasites, 1977.

Citrus pest or parasite	Acaraben	Kelthane®	Vendex®	Zineb	Ethion	Trithion®	Sulfur	Carzol S.P.	Oil	Supracide	Guthion®	Malathion	Parathion	Sevin	Copper	Cygon®
Citrus rust mite	4	4	4	4	4	3-4	2-3	3	1	0	1	0-1	0	-	a	0
Texas citrus mite	1-2	4	4	0	3-4	3-4	1-2	3-4	3-4	d	2-3	1-2	1-2	d	a	3
False spider mites	4	4	-	0	c	c	3	-	3	-	d	-	-	-	-	-
Chaff scale	N	N	N	N	a	b	b-c	c	4	4	4	2-3	3-4	d	a	-
California red scale	N	N	N	N	N	a	b-c	c	3-4	3-4	3-4	2-3	3-4	d	a	-
Purple scale	N	N	N	N	N	a	c	-	4	4	3-4	-	3-4	d	a	-
Florida red scale	N	N	N	N	-	-	c	c	4	4	-	-	3-4	d	a	-
Brown soft scale	N	N	-	-	1-2	3	-	a	3	4	4	3	d	4	-	-
Citrus mealybug	N	N	-	N	a-b	-	-	-	1-2	3-4	2	2-3	-	-	-	2-3
Parasites:																
Ext. chaff scale	N	N	N	N	b	c	b-d	c-d	a	c-d	c-d	b-c	d	d	a	a-b
Int. chaff scale	N	N	N	N	b	c	b-d	c-d	a	c-d	c-d	b	d	b	a	a-b
Ext. CA red scale	N	N	N	N	c	c	b-c	d	a	b-c	d	d	d	d	a	-
Ext. purple scale	N	N	N	N	c	c	b-c	-	a	-	d	d	d	d	a	-
Ext. FL red scale	N	N	-	-	c	c-d	c-d	c-d	a	c	d	d	d	d	a	-
Int. brown soft scale	-	-	-	-	-	-	d	-	a	-	d	d	d	d	-	d

Numbers: 0 to 4 = degree of kill by pesticide. Letters a lowest to d highest = degree of increase of scales or mites, or degree of reduction of parasites found. N = no effect noted. (-) = no information. (Ext.) and (Int.) = external and internal parasites.
SOURCE: Texas Agricultural Experiment Station and Citrus Insects, ARS, USDA, Weslaco, TX.

good. Some people have considered this as a suppressive means of control when the ground is too wet for a ground sprayer. When 250 gal. of mixture/acre are applied with a ground sprayer, adequate control of this pest has generally been accomplished. Greater numbers are usually found on leaves and fruit on the east side of the trees and in the northeast quadrant (4).

Texas citrus mites — The largest increase in populations of this pest during the year is generally found during the May to June period, although increases in numbers have been found during other periods of the year. Hot and dry weather conditions have been associated with such increases in numbers. During extended periods of rainy weather, a high incidence of infection was found by a beneficial fungus, *Entomophthora floridana* Weiser and Muma. Greater numbers are present in the upper portion of the tree with smaller numbers on leaves in skirt and inside areas of the tree (8). Preference was shown for leaves on the south side of the tree (4).

Sulfur had been used for many years. Suppressive control was found in numerous instances while sharp increases in Texas citrus mite populations occurred following sulfur applications in a number of cases. Kelthane has provided good selective control in most instances, although some reduction in effectiveness was found when mites were on the young flush and fruit. The authors have found long residual control with Vendex when good coverage is attained but good coverage can be a limiting factor in control with this material. Oil, with good coverage, has provided very good control (10). Certain beneficials of armored scales have worked together with oil, Kelthane, and Vendex. Observational kill of this mite by a beneficial fungus was reduced following copper applications. Ethion, Trithion, and Carzol S.P. have provided effective control, but certain beneficials were killed with their usage and chaff scales have increased in number after the use of Trithion (18). Texas citrus mites have increased following continued use of Guthion, and particularly large increases in numbers have followed Sevin, Supracide, and sulfur. Variable results in control have been found when the above-named pesticides have been applied to high populations, particularly during the summer period.

False spider mides — These mites were not a problem when sulfur was the principal agent for citrus rust mite control. In 1959, growers began use of zineb for citrus rust mite control. Zineb did not provide control of false spider mites. In 1966, a false spider mite problem developed for growers using Guthion for control of all Texas citrus pests (15). False spider mite injury of fruit also occurred when ethion and Trithion were used without the addition of an effective controlling agent. Guthion killed the movable forms of mites, but when eggs hatched, their numbers rapidly increased to damaging levels. These organophosphates and certain carbamates were very toxic to benefical mites. Data showed that false spider mites were seldom recorded following applications of Kelthane, Acaraben, oil, and sulfur.

Armored scales — A greater portion of research time in Texas has dealt with chaff than California red scales because 20X, or greater, of the former have been found. Parasites have increased at an earlier date following oil than any of the organophosphate (3, 14, 16) pesticides. Populations of chaff and California red scale parasites have been affected very little following the use of Acaraben, Kelthane, oil (generally less parasite kill), Vendex, and zineb. Increases in chaff, California red, and Florida red scales were found after the second Carzol S.P. application while parasites of these species were present only in negligible numbers. Sevin failed to provide control of the principal armored scales whose parasites were deciminated after one application. Malathion did not provide as good control of chaff and California red scales as parathion, but the latter pesticide was followed by rapid increase in brown soft scales (19). Increases in populations of several armored scales were found following continued usage of sulfur and after copper sprays. Parasite numbers were larger in counts where these two pesticides were not used. Oil, Supracide, and Guthion have provided some of the best control of armored scales (5). Some armored scales were found to increase in numbers after ethion or Trithion were applied alone with some notable increase of chaff scales following Trithion (18). The live scale count did not change much after Cygon, but chaff scale parasites were reduced. An effective purple scale parasite was introduced in 1952 (7). The only groves where purple scales have been a problem during the last 7 years are those groves where Sevin, Carzol S. P., or certain of the organophosphorus pesticides have been used and have upset an effective scale to parasite relationship. Florida red scales have been effectively controlled a few years after an effective parasite was introduced in 1959. Florida red scales have increased in numbers in recent years following applications of the same pesticides found associated with increases in purple scales (unpublished). It was interesting that Sevin reduced the internal parasite of chaff scale only 50% while the external parasite was eliminated after one application (13). Full coverage of all parts of the tree is essential if armored scale control is attained. Higher gallonage from a ground sprayer traveling at 1 mph is required if pesticidal control results.

Brown soft scale — Since 1959, this scale insect has been a problem predominately as a result of parathion drift from cotton (19). The use of parathion as a controlling agent for armored scales in citrus will be followed by large increases in brown soft scale (10). Guthion, Supracide, and Sevin have been the best controlling agents, but certain other pest p oblems are related to their use. Oil will provide suppressive action against this scale insect and parasites are not eliminated (11). Oil will not control heavy infestations of brown soft scale, but does provide help in release of the black sooty mold fungus which grows in the honeydew secreted by this scale insect. Other problems which are associated with the best controlling agents would suggest "spot treatment" as a good pest management procedure except where parathion drift from cotton affects the entire grove. Color infrared photography from aircraft offers promise as a pest management tool for delimiting infested areas of groves (20). Control of those ants which infest the trees is a good practice to effect better brown soft scale control by parasites and predators (which are affected or killed by these ants). Grapefruit is preferred to oranges as a host of brown soft scale.

Citrus mealybug — This insect became a major problem in one area of Valley citrus in 1970 following the consistent use of organophosphorus pesticides. Once the mealybug becomes established under the button of the fruit or under heavy fungus deposits, pesticidal control has not been very successful A number of pesticides are shown in the table which provide various levels of control, but timing and coverage is extremely important if the desired results are to be attained. A black hymenopterous wasp and a brown lacewing have provided significant natural control if pesticides do not upset the mealybug to beneficial insect relationship (12). Numerous growers have found their mealybug problem to subside when organophosphorus pesticides have not been used. Citrus mealybug is seldom a problem in orange trees but has been a major problem in grapefruit trees in many instances.

A flatid planthopper — *Metcalfa pruinosa* (Say). This planthopper usually hatches from the egg in mid-March with adults showing up in early May (9). Only 1 generation a year occurs. Grapefruit trees are favored, and when the nymphs are numerous and secrete considerable honeydew (during very hot and dry conditions), pesticidal control may be advisable. The lack of evidence that fruit drop occurs makes pesticidal control questionable. During certain years, a dryinid parasite becomes very abundant attacking the nymphs underneath the wing pad.

Barnacle scale — This wax scale has been found on rare occasions in past years. However, large numbers were found in 1975 in certain groves. It can be assumed that the scale to beneficial insect relationship was upset by phosphorus pesticides. A single instance was found where Kelthane (only) was applied three times each in 1975 and 1976 and barnacle scale increased to heavy numbers in grapefruit (unpublished). Numerous primary parasites were consistently found, but numbers of hyperparasites were, at times, sufficiently high to have caused a reduction in effectiveness by the primary parasites. In 1954, a single tristeza-infected lemon tree (when caged in the field) had large numbers of this wax scale. Ant control was followed by a quick reduction in numbers of scales and more effective parasitism. Supracide provided some of the best pesticidal control.

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Flavanone Content of Freeze-induced Aggregates in Segment-Walls of Oranges [*Citrus sinensis* (L.) Osbeck]

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ABSTRACT

Microscopic examination showed that white specks in the locular membranes of freeze-injured oranges were amorphous. Samples of freeze-damaged membranes with specks and without contained hesperidin, neoponcirin, and narirutin. The total flavanone contents of the air-dried membranes were 4.52% by weight for the sample with specks and 3.44% for the control sample.

Freeze damage to citrus fruit can cause changes, both structural and chemical, that lowers their market value. Structural changes alter both the appearance and texture of the fruit, expecially of the edible portion. Structural collapse of tissues and cells leads to chemical changes; and these can directly alter the quality of the fruit or juice and initiate further physiological changes which shorten the shelf-life of the fruit.

The degree of freeze damage sustained by fruit is related to several factors: the minimum temperature of exposure, the duration of exposure to damaging temperatures, and the physiological condition of the fruit at the time of exposure. Most commonly, damage in thawed fruit is manifested by a whitish milky appearance of the fruit sections and decreased turgor of the juice sacs. Desiccation of the juice sacs and segments appears to be progressive, and small white specks may appear in the segment walls within a week of the freeze.

Webber, in his assessment of the Florida freezes of 1894 to 1895 (10), made the observation that: "In frozen oranges white specks, frequently as large as half a millimeter in diameter, form in the membranes between the segments and in the membranes of the pulp vesicles. They are so invariably present in frozen oranges, even where the fruit is but slightly injured, that they may be considered as evidence of the effect of freezing." Webber then speculates that: "These specks are apparently masses of hesperidin cyrstals, separated from the cell sap by chemical changes caused by freezing." No evidence was offered to support this speculation; in fact, his next sentence tends to refute it: "These characteristic specks are also found in frozen lemons and pumeloes (grapefruit), and probably in all citrus fruits." It is now known that the grapefruit contains only very minor amounts of hesperidin (3) and it is entirely lacking in some other citrus species (1).

Milliken et al. (6), in their study of the 1913 California freeze state: "One of the earliest internal indications of frost damage in citrus fruits is the formation in the membranes or pulp of small white spots or crystals of hesperidin." They gave no chemical evidence, nor did they cite any primary source as basis of their statement.

Hall (4) characterized the specks as being crystalline aggregates of hesperidin, the major flavanone of oranges. He observed that these aggregates appear within a few days after fruit of either 'Navel' or 'Valencia' oranges had been frozen on the tree. The aggregates persisted for as long as three months in 'Navel' and eight months in 'Valencia' oranges. Hall gave no evidence to indicate that the aggregates were truly crystalline. He did, however, find chemical evidence which led him to conclude that "the crystals on the endocarp of frozen navel oranges consist of hesperidin." Subsequent workers (2, 3, 4) have continued referring to the aggregates as hesperidin crystals without providing any additional evidence.

Tunmann has shown (9) that hesperidin can occur in either crystalline or amorphous form within the vacuoles of cells which have been treated with various solvents or have been partially dehydrated. This evidence, along with the known limited solubility of hesperidin in water would be consistent with the argument that the white specks in the segment-walls of freeze damaged oranges could consist of hesperidin. However, this has not been conclusively proved.

Modern chemical techniques for characterizing and quantitating natural products on a microscale and the expanded knowledge (1) of minor flavanone compounds in citrus would appear to allow closer study of these so-called aggregates. We therefore undertook to examine them microscopically and to determine their flavanone composition.

MATERIALS AND METHODS

During the first week of February, 1975, fruits were randomly harvested from 'Marrs', 'Hamlin', 'Pineapple', and 'Valencia' orange trees at an experimental grove on the Texas Agricultural Experiment Station, Weslaco.

The fruits were examined both externally and internally for evidence of damage from a mid-January freeze.

Locular membranes containing the aggregates were removed from sections of the 'Valencia' oranges, laid flat on 75 x 50 mm microscope slides, and air dried for 24 hours. Then they were cut transversely through the aggregate into slices about 200- m thick. These thin sections and the membrane itself were microscopically examined in cross-section by use of transmitted polarized light and a crossed polarizing analyzer screen at the eyepiece.

For chemical analysis, those portions of flattened dried membranes containing aggregates were removed as 1 to 2-mm squares. These were cut as close to the aggregates as possible but were not trimmed. A total of 28 mg of aggregate-containing squares were collected. From the same membranes but in areas devoid of aggregates 28 mg of 1 to 2 mm squares were obtained as a control sample.

The samples were each ground in a micro mortar with 1 g of ignited Ottawa fine sand. The homogenates were successively extracted with six 1 ml portions of pyridine. The last extract was devoid of fluorescent material. The extracts were combined and brought to a volume of 7 ml.

The pyridine extracts were applied directly to polyamide thin layer chromatographic plates and the chromatograms developed with a nitromethane-methanol (5:2 v/v) solvent system. For quantitative analysis each thin layer plate was spotted with three 50- l replications of the aggregate and control extracts as well as three 10- l replications of a standard naringin solution. Duplicate sets of plates were run. The individual spots identified as flavanones were quantitated microfluorometrically according to Hagen et al. (3).

RESULTS AND DISCUSSION

On the nights of January 13th and 14th, 1975, the lower Rio Grande Valley had sub-freezing minimum temperatures. An official National Weather Service station located within 200 m of the orange grove recorded minimums of -3.9 and -2.8°C (25 and 27°F) for the two respective nights. Table 1 shows the duration of freezing conditions at or below specified temperatures. The days before and after the freeze both had mimimums of 3.3°C (38°F). The average minimum for the month was 12.3°C (54°F).

Table 1. Duration of freezing temperatures for the January 13 to 14th, 1975 freeze.[1]

Hours and minutes at or below specified temperature.

	Temperature							
	0°C (32°F)	-.6 (31)	-1.1 (30)	-1.7 (29)	-2.2 (28)	-2.8 (27)	-3.3 (26)	-3.9 (25)
1st night	10:00	7:40	6:10	5:15	3:40	2:00	1:10	
2nd night	6:10	5:50	5:05	4:00	2:10	0:40		

1 From records of the National Weather Service station maintained at the Texas Agricultural Experiment Station, Weslaco.

Three weeks after the freeze only those oranges from the upper, south-facing part of the tree showed aggregates in the locular membranes. These symptoms were the same for all varieties examined. No other symptoms of freeze damage was apparent at that time.

Fig. 1-A shows the typical distribution of aggregates on the radial face of a segment in the locular membrane. The aggregates are generally smaller and fewer in number near the ends of the segments. The largest aggregates are found near the central axis of the fruit.

Fig. 1-B shows the irregular shapes of the aggregates. The specks were rounded and definitely did not resemble the needle-like crystals of hesperidin. Fig. 2-A shows a rectangular portion of the dried locular membrane viewed by use of transmitted polarized light and crossed polarizers. The membrane material itself was relatively transparent and rotated the plane of the light sufficiently to appear bright against the dark background. This is due to the anisotropy of crystalline cellulose in miscelles which are birefringent. The darker portion of the rectangle represents the aggregate. The aggregate had neither the transmission of birefringent properties that Tanmann (9) reported to be characteristic of crystilline hesperidin. Fig 2-B shows that the aggregate material is diffused into the tissue of the locular membrane, and shows why we were unable to tease discrete aggregates from the membranes. We concluded that the aggregates are not crystalline and not discrete entities but are an amorphous accumulation of solids within the confines of cellular tissue.

Table 2 lists the quantities and identities of the flavanones present in the two samples. Nirirutin, hesperidin, and neoponcirin are all flavanone rutinosides and have been previously identified in oranges. A fourth very faint spot was also observed on the chromatographic plate; it had migration properties similar to hesperetin, the aglycone of hesperidin.

Because of the small amount of materials available, we could not prepare replicate samples; so we are not able to say whether the observed increases in flavanone concentrations found with the aggregates are real. More important, however, is the relatively small differences in the amount of total flavanones between the samples without and with aggregates, respectively, 962 g (3.44%-by weight) and 1266 g (4.52%-by weight). Thus, active transport of flavanone material to the site of aggregate formation appears not to be a prerequisite for their formation.

It is not possible to determine from this study whether or not one or more of the flavanones present in the membrane tissue make up the white specks. However, the specks do not appear to be crystalline. Hall's isolation of hesperidin from membrane aggregates is not unique since membranes containing no aggregates have similar amounts of hesperidin. The flavanones extracted from the samples with specks could have been present not in the specks but in the surrounding membrane; and the specks themselves could have consisted of non-flavanoid compounds.

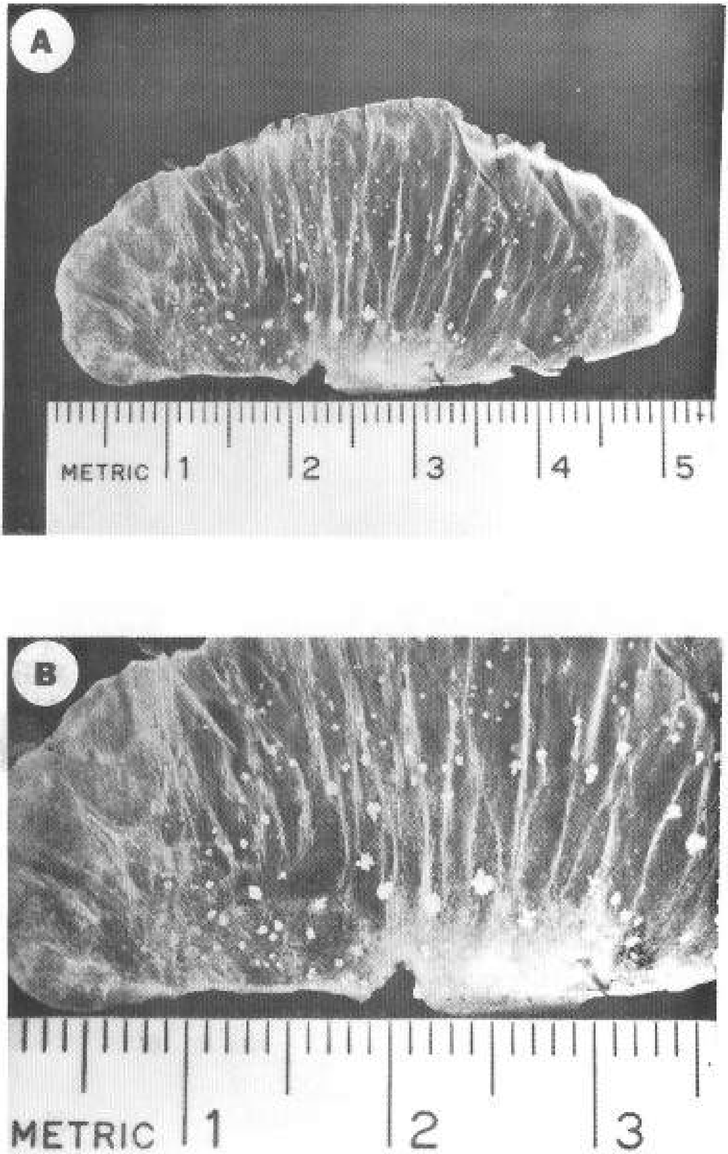

Fig. 1. Locular membrane from the radial face of a freeze-damaged 'Valencia' orange segment.

A. 1.6 X
B. 2.7 X

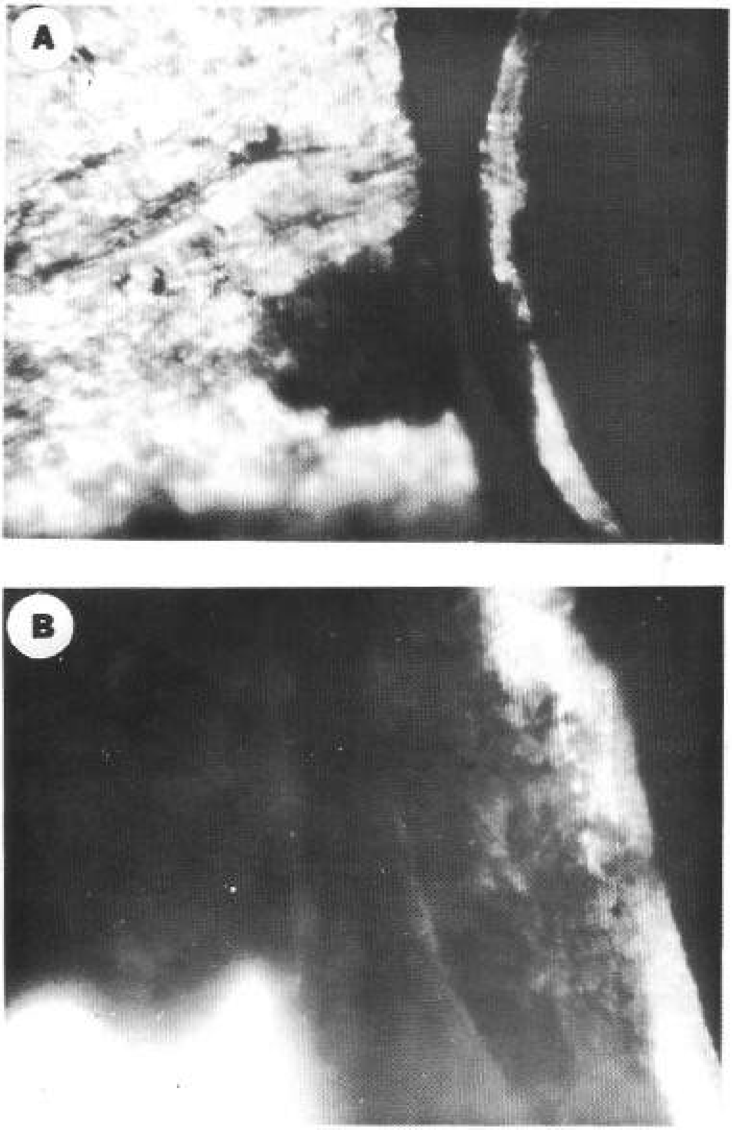

Fig. 2. Photomicrographs of section of dried locular membranes of a freeze-damaged 'Valencia' orange segment. Portion on right is a thin slice from the adjacent membrane placed on edge. Both views by transmitted polarized light with crossed polaroids.

A. 40 X
B. 150 X

Table 2. Flavanone content in 28 mg portions of dried segment walls with and without aggregates.

Flavanones [2]	Micrograms found [1]		
	Narirutin (CV)[3]	Hesperidin (CV)	Neoponcirin (CV)
Without aggregates	204 ug (3.8%)	640 ug (3.9%)	118 ug (3.6%)
With aggregates	286 (9.7%)	764 (1.4%)	216 (4.7%)
Percent increase with aggregates[4]	40%	19%	83%

1. Replicated three times on each of two TLC plates.

2. Narirutin = isonaringin = 7-rutinoside of naringenin
   Hesperidin = 7-rutinoside of hesperetin
   Neoponcirin = 7-rutinoside of isosakuranetin

3. Coefficient of variablility.

4. Based upon a one-way analysis of variance, the differences between the aggregate and non-aggregate sample are significant at the 90% level.

One class of compounds worthy of consideration in this regard are the waxes. Shomer et al. report finding in juice sacs of grapefruit local inflations of the wax layer with large bizzare-shaped protrusions in some cases forming aggregate structures. Some wax structures appear to have melted and fused to form bizarre masses.

Since no evidence is available which would rule out the possibility that aggregate formation could be due to phenomena unrelated to the presence of hesperidin or other flavanones in citrus tissue, and because they are not crystalline; they should not be referred to as hesperidin crystals.

Further work is necessary to fully understand the nature of these white specks in the segment walls of freeze-damaged citrus.

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Content and Seasonal Variation L-Ascorbic Acid in Texas Ruby Red Grapefruit

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ABSTRACT

Individual lots of Texas Ruby Red grapefruit (*Citrus paradisi* Macf.) vary widely in L-ascorbic acid content but generally average 30-35 mg%, a level which equals or exceeds the minimum (30 mg%) generally accepted by the citrus processing industry. The L-ascorbic acid level tends to decrease somewhat with advancing maturity of the fruit. On the basis of the means, the variations are within acceptable limits of the new nutritional labeling regulations.

The Ruby Red grapefruit (*Citrus paradisi* Macf.) is the principal fruit grown in the South Texas citrus producing area. About 40 to 45% of the crop is processed. To expand the market for processed citrus, particularly grapefruit, our laboratory has taken considerable data on the internal quality of the fruit (1, 2, 3). In this paper data for the analyses of L-ascorbic acid (Vitamin C) content and variation during several harvest seasons, are presented and compared with data for Ruby Red grapefruit juice reconstituted from samples of commercial concentrate.

The L-ascorbic acid content of citrus generally peaks shortly before maturation and then declines during ripening and senescence (4 to 13). Three major freezes (1949, 1951, 1962) in the lower Rio Grande Valley essentially eliminated from commercial production, all grapefruit varieties except the Ruby Red. Metcalfe et al. (5) and Krezdorn, and Cain (10) examined Marsh, Duncan, and Foster; and Marsh, Thompson and Redblush varieties, respectively. As a result, new data were desired on plantings made since 1962. Cohen (14) explained the considerable L-ascorbic acid variation in citrus by showing that the formation of the vitamin depends on the intensity of the light and the area of the fruit over which light is received. Accordingly, because differences in L-ascorbic acid depend on the position of the fruit on the tree, careful sampling of the fruit in the field is necessary to reduce variability within a lot.

MATERIALS AND METHODS

Five groves, located in the major citrus producing areas of the Lower Rio Grande Valley of Texas, were chosen as locations. All groves were under professional care. One grove was located in the eastern area, near La Feria, Texas; one near Monte Alto in the northern area; and three in the Mission-McAllen-Edinburg triangle, in the major western citrus production area. Eight trees of Ruby Red grapefruit were selected in each grove located, where possible, in a block of two rows of four trees each. On occasion, due to light and widely variable sets of fruit, this arrangement was not feasible, and trees having good sets of fruit were chosen in a close proximity to each other as possible within the individual groves. This arrangement could be analyzed by use of a complete randomized block design, with the groves as replicates. Field run fruit were gathered biweekly; seven fruit were picked completely at random from the circumference of each tree. Care was taken that all quadrants of the trees were represented, as well as the interior and exterior sections. Picking heights ranged from ground level (perhaps 2 to 3 inches) to about 6½ ft. On occasion, a ladder was used toward the end of the season to extend picking heights to about 10 ft. Each sample thus contained 56 separate fruit per sampling date. An additional quantity of fruit was picked separately for priming the extractor.

The fruit were washed on a set of motor-driven brush rolls, and the juice extracted with a FMC Model 091B in-line test extractor fitted with 0.027-inch screens, and pressurized at 18 psig. The juice was deaerated at 30-inches vacuum. L-ascorbic acid was determined by the colorimetric procedure of Nelson and Somers (15) and reported as mg%. Data on L-ascorbic acid were obtained over three harvest seasons, and subjected to analysis of variance by use of a computer, programmed in a randomized block design.

L-ascorbic acid was also determined on Ruby Red grapefruit juice, prepared from commercial concentrate manufactured during two harvest seasons and reconstituted to 10° brix. A total of 50 samples for the two seasons was analyzed. An unpaired statistical calculation was made, with season as a variable.

RESULTS AND DISCUSSION

Within a season, L-ascorbic acid in Texas Ruby Red grapefruit varied considerably (Table 1), and the decreasing trend reported in the literature as maturity progressed was not well-defined. Values in this table represent juice in the brix/acid ratio ranges that meet USDA Grade A standards for processing (16, 17). The sampling periods of Table 1 were selected to represent periods of harvest during the time when a major portion of the processed products are produced.

Table 2 presents a three-season mean and standard deviation. Variation was similar to that shown in Table 1. The three-season mean was calculated to obtain an expectation of the mean over an extended period. Sampling periods of this table were selected to represent periods of harvest when most of the grapefruit in Texas is harvested including both fresh and processed.

The variation within a single season, as reported in Table 1, ranges from a low of 31.6 mg/100 gm to a high of 42.2 mg/100 gm while the variation among

Table 1. Mean* L-ascorbic acid content—Texas Ruby Red grapefruit—1970 to 1971

Sampling period									Mean
1	2	3	4	5	6	7	8	9	
36.2	36.8	32.4	35.4	41.6	42.8	33.2	39.6	31.6	36.6

*Each value represents the mean of five determinations, one from each of five groves

Table 2. Mean L-ascorbic acid content—field run Ruby Red grapefruit.

Season	No. of sampling dates	Total no. of individual samples	Mean L-ascorbic acid content, Mg%	Standard deviation
1970 to 1971	14	70	34.7	5.5
1971 to 1972	16	79	30.2	4.0
1972 to 1973	12	60	32.1	4.6
Three - season total	42	209	32.2	5.1

seasons, as indicated in Table 2, ranged from 30.2 mg/100 gm to 34.7 mg/100 mg. Apparently ascorbic acid content varies greatly between individual groves and variation could be wide in fruit marketed fresh fruit.

Table 3 summarizes the individual L-ascorbic acid analyses of 28 samples of grapefruit juice reconstituted from concentrate prepared on the indicated date to 10° Brix in the 1973 to 1974 season and 22 samples similarly prepared and analyzed in the 1974 to 1975 season. Some values were below 30 mg%. The cause of the low values is not known, but packing shed culls are included in the fruit

Table 3. L-ascorbic acid — reconstituted grapefruit juice* from commercial concentrate.

1973 to 1974 season		1974 to 1975 season	
Date concentrate prepared	L-ascorbic acid, mg%	Date concentrate prepared	L-ascorbic acid, mg%
12/30/73	36.4	10/15/74	38.8
1/3/74	37.5	11/12/74	36.0
1/8/74	34.7	1/7/75	34.3
1/12/74	35.8	1/17/75	33.7
1/17/74	35.4	1/22/75	34.0
1/18/74	30.0	1/29/75	29.2
1/19/74	35.8	2/1/75	33.7
2/5/74	31.2	2/2/75	30.0
2/13/74	34.0	2/5/75	31.2
2/18/74	34.0	2/8/75	28.3
2/21/74	32.3	2/10/75	29.2
2/23/74	34.3	2/12/75	43.6
2/27/74	39.0	2/17/75	38.4
3/1/74	34.3	2/19/75	34.0
3/2/74	34.0	2/24/75	30.0
3/4/74	30.0	2/26/75	31.7
3/5/74	30.3	2/28/75	35.6
3/10/74	33.0	3/3/75	28.3
3/11/74	30.3	3/5/75	31.6
3/11/74	28.0	3/6/75	32.0
3/20/74	37.6	3/13/75	34.0
3/22/74	32.3	3/14/75	34.0
3/23/74	42.0		
3/25/74	35.8		
4/10/74	29.2		
4/19/74	28.0		
4/22/74	31.7		
5/10/74	34.3		

*Reconstituted to 10° Brix

processed, so poor handling or extended storage might contribute to these low values. The mean, however, is above the 30 mg% level.

Table 4 correlates the mean and variance of the two seasons of reconstituted commercial concentrates. Despite the variation in individual values, the means of the two seasons are not significantly different. Again, although the late-season L-ascorbic acid values are lower in most respects than early-season values, the trend is only suggested.

Table 4. Correlation of mean L-ascorbic acid content of grapefruit juice from commercial frozen concentrate*

Season	No. of samples	Mean, mg%	Variance	Standard deviation
1973 to 1974	28(x)	33.6	11.2	3.3
1974 to 1975	22(y)	33.3	14.1	3.7

Unpaired—equal, unequal
Mean difference—0.36
Variation of difference—1.01
Standard deviation of difference—1.005
T-Ratio— 0.357

*Reconstituted to 10° Brix

In both the experimental and commercial samples no values varied by more than 20% from the means. This variance is within the tolerances allowed by the new nutritional labeling regulations of the U.S. Food and Drug Administration.

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The Content & Seasonal Variation of L-Ascorbic Acid in Texas Oranges

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ABSTRACT

The L-ascorbic acid contents of commercial Texas oranges were primarily a function of the fruit variety. Hamlin oranges contained the highest level (ca. 48 mg/100 gm juice), then Marrs (ca. 38 mg) and Valencias (ca. 37 mg). The Valencia and Marrs ascorbic acid contents were more variable than the content in the Hamlin; differences between Valencia and Marrs were not significant over a 3-year period. Wide variations in L-ascorbic acid were encountered from one lot of fruit to another. The means for each sampling date differed from the season mean by no more than 20%, the tolerance permitted by the new nutritional labeling regulations.

In connection with utilization studies (1,2) on Texas citrus, a study was made of the L-ascorbic acid (vitamin C) content in freshly-extracted raw orange juice during the harvest seasons to provide specific and current data on the content and variation of this component in Texas oranges, during the 1970 to 1971 harvest season and the means for three harvest seasons.

The L-ascorbic acid content of citrus generally reaches a peak shortly before maturation, and then declines during ripening and senescence, with the actual content varying widely with variety and region (3 to 14, 16 to 18). Texas fruit were investigated by Metcalfe et al. (Hamlin, Valencia and Temple oranges, and Marsh, Duncan and Foster grapefruit, 7); and by Krezdorn and Cain (Marsh, Thompson and Redblush grapefruit, 14). Three important freezes (1949, 1951, 1962) that occured since Metcalfe's work have resulted in some changes as to the commercial varieties grown, particularly those used for both fresh market and processing. Currently, Marrs and Hamlins comprise the bulk of the early maturing orange varieties. Valencia oranges remain the major late-season variety. The harvest season—about October 15 to February 1 for Marrs and Hamlins, and January 15 to May 15 for Valencias—are subject to some variation, particularly due to the pre-season climate. For example, heavy unseasonal rains in May and June of 1972, and a lack of the usual September rain caused the crop to ripen some 2 to 3 weeks earlier than in the previous 4 years. Cohen (15) indicated that the formation of L-ascorbic acid in citrus is dependent upon the intensity of the light, and the area of the incidence on each fruit. Thus, even the fruit from one tree may be expected to differ in L-ascorbic acid content.

MATERIALS AND METHODS

Five groves, located in the major citrus producing areas of the Lower Rio Grande Valley of Texas, were chosen for study. One grove was located in the eastern area, near La Feria, Texas; one near Monte Alto in the northern area; and three in the Mission-McAllen-Edinburg triangle, in the major western citrus production area. All orchards had professional grove care. Eight trees of each of the three major varieties of oranges were selected in each grove and were located in a block of two rows of four trees each where possible. On occasion, when light and widely variable sets of fruit precluded this arrangement, trees having good sets of fruit and in as close proximity to each other as possible within the individual groves were chosen. The variances found were statistically analyzed by use of a complete randomized block design, and the groves were used as replicates. Field run fruit were gathered at biweekly intervals; seven fruit from the circumference of each tree were picked completely at random. Picking heights ranged from ground level (perhaps 2 to 3 inches) to about 6.5 ft. On occasion, a ladder was utilized toward the end of the season to extend picking heights to about 10 ft. Each separate sample of each variety thus consisted of 56 fruit per sampling date. Additional fruit were picked separately for priming the extractor.

The fruit in each sample were washed on a set of motor-driven brush rolls, and the juice extracted using an FMC Model 091-B in-line test extractor fitted with 0.027-inch screens, and pressurized at 18 psig. The juice was deaerated at 30-inches vacuum. L-ascorbic acid content of the deaerated juice was determined colorimetrically according to Nelson and Somers (19), and reported as mg/100 gm juice. (mg%) Data were gathered for three growing seasons.

Data on Marrs, Hamlin, and Valencia oranges from 1970 to 1971 season were statistically evaluated by analysis of variance with an IBM computer programmed for a randomized block design. The 1970 to 1971 season was considered to be climatically ideal (average amount of rainfall in May, June and September; no hurricanes or other disasterous wind conditions, and no damaging cold weather). The fruit were picked during the peak harvest season for fresh fruit (as contrasted to fruit for processing). Thus, the sampling dates for the three cultivars did not necessarily coincide. Similarly, for each cultivar, sampling dates in the three seasons did not coincide, due to maturity variation. In the three-season mean, only 10-week harvest periods (five biweekly samples) could be properly compared because of a short Valencia harvest in the third year, but those 10 weeks for each variety represented the peak harvesting season in all three years. Since Valencia mature much later than the early varieties, the entire orange harvesting period covered from 20 to 22 weeks each season.

RESULTS AND DISCUSSION

The mean L-ascorbic acid contents of the three major Texas orange varieties appeared to differ with the variety (Table 1), and varied considerably throughout the 1970 to 1971 season; generally though, the L-ascorbic acid content was lower at late than at early maturity. The mean variation among the varieties was

Table 1. Mean* L-ascorbic acid content mg%—Texas oranges—1970-1971.

Variety	Sampling period 1	2	3	4	5	6	7	8	9	Mean
Hamlin	56.6	48.0	47.6	49.8	51.0	50.2	48.8	48.2	47.0	49.7 a
Marrs	47.0	42.2	44.8	42.2	42.4	42.4	39.2	38.2	34.0	41.4 b
Valencia	35.4	29.4	27.2	28.0	40.4	32.4	38.8	31.2	29.2	32.4 c

*Each value represents the mean of five determinations, one from each of five groves.

Table 2. Three-season mean *L-ascorbic acid of three major Texas oranges, mg%.

Variety	Mean 1970 to 1971	Mean 1971 to 1972	Mean 1972 to 1973	Three-season mean
Hamlin	50	46	45	47 a
Marrs	42	35	36	38 b
Valencia	31	37	44	37 b

*Each mean represents 25 samplings, five from each of the groves, at biweekly intervals.

significant at the 1% level. Hamlin oranges had the highest ascorbic acid level for each of the sampling periods and Valencia the lowest.

The three-season means (Table 2) showed that the L-ascorbic acid content of the Hamlins was significantly higher (47 mg%) (Duncan's test, $p < 0.05$) (20) than that of either the Marrs (38 mg%) or Valencias (37 mg%); however, the L-ascorbic acid content of Valencias for the 1972 to 1973 season was unusually high and thus raised the three-year mean nearly to that for the Marrs fruit. In that season, Valencias grown throughout the Lower Rio Grande Valley of Texas had high levels of L-ascorbic acid, possibly due to a light set of fruit.

We did not correlate the variability in L-ascorbic acid values from one sample to another with any agricultural practices. All three orange varieties contained, on the average, more than 30 mg% L-ascorbic acid, a level generally considered by the citrus processing industry to be an acceptable minimum. On the basis of variety, the L-ascorbic acid values for each sampling date, despite their variance, differed by no more than + 20% from the season means. This is within the tolerance established under the new nutritional labeling regulations of the U.S. Food and Drug Administration.

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Nucellar vs. Old-line Red Grapefruit: Yield and Growth Through 16 Years

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Abstract

Fruit yield and size and tree growth of 12 different nucellar red grapefruit selections and old-line Ruby Red were compared for 10 seasons (seventh through sixteenth year). Yields of the nucellars were equal to or greater than the old-line over this period except for the nucellar of most recent seedling origin. Fruit sizes of the old-line Ruby Red and the nucellar California Red No. 3 were smaller in some years than some nucellar selections. No consistent fruit size-crop size relationship could be determined. Tree growth in height, width, and trunk diameter was greater with the nucellars than the old-line. This greater tree growth required the planting to be hedged four times and topped once during the first 14 years.

A planting of one old-line and 12 nucellar red grapefruit selections was established at the Texas A & I University Citrus Center in June 1960. The purpose was to determine if nucellar trees, derived from old-line red grapefruit varieties, would be superior in fruit production to the old-line Ruby Red. Yield and growth of this planting through the first nine years was reported by Hensz (1) in 1970.

Early yields favored the old-line Ruby Red, then production became even, and by the ninth year all 12 of the nucellar selections outyielded the old-line. The Fawcett Red nucellar had been propagated for this planting directly from a one year old seedling. It was slow to come into bearing and had the lowest cumulative yield after nine seasons. This same variety had the greatest growth in trunk diameter, indicating the tendency to rapid vegetative growth that recently-developed nucellar trees are noted for. The old-line Ruby Red had significantly less trunk growth than the 12 nucellar selections and tree height and width was also less.

The 13 grapefruit selections showed wide ranges of yields between highest and lowest producing trees within each selection.

This report covers production and growth of the trees in this experiment for a 10-year period including the seventh through sixteenth years.

MATERIALS AND METHODS

Twelve nucellar red grapefruit selections grown from seed of seven old-line red grapefruit varieties were compared in yield and growth with the old-line Ruby Red in a performance test at the Texas A & I Universtiy Citrus Center. The trees were planted in June 1960. Listed as follows is the approximate year of seedling origin for the nucellar clones.

Selection	Approximate year seed planted
A. Nucellar California Red No. 3	1945
B. Nucellar Redblush (RFR13T3)	1950
C. Nucellar Redblush (CCR24T2)	1953
D. Nucellar Redblush (CCR23T2)	1953
E. Nucellar Redblush (CCR22T5)	1953
F. Nucellar Redblush (CCR20T3)	1953
G. Nucellar Riddle Redgold	1950
H. Nucellar Fawcett Red	1958
I. Nucellar Shary Red	1952
J. Nucellar Langford Red No. 1	1949
K. Nucellar Curry Red Radiance	1950
L. Nucellar Ruby Red	1949
M. Old-line Ruby Red	N/A

The nucellar California Red No. 3 originated from Redblush seed planted in California. The rest originated in Texas. Selections B, G, J, K, and L were obtained from Dr. E. O. Olson, U.S.D.A.-ARS, Weslaco, The selections C, D, E, F, and H were grown from seed at the Texas A&I University Citrus Center, Weslaco. Law Nursery in McAllen provided selection I and the old-line Ruby Red was obtained from Hughes Nursery, Elsa, Texas.

Sour orange was used as the rootstock and the orchard was planted on Hidalgo sandy clay loam. Sod culture was practiced for four years following planting, and then it was converted to chemical weed control. The young trees were frozen to their insulating wraps in January 1962, when they were 1½ years old. Nitrogen at 1-1½ lb. tree/year applied once each year in the fall or winter, has been the fertilizer program.

Tree rows run east to west with tree spacing 20 x 22 ft, or 100 trees/acre.

Due to growth and crowding, principally from the nucellars, it has been necessary to hedge-prune the planting four times and top once during the first 14 years of the planting.

Feb. 1968 - Hedged north and south sides 7 ft from trunk.
Feb. 1970 - Hedged north and south sides 6 ft from trunk.
Feb. 1973 - Hedged north and south sides 6 ft from trunk.
Feb. 1975 - Hedged all sides, north and south sides 6 ft from trunk; east and west sides 4-5 ft from trunk; topped 9 ft from ground.

Tree growth was determined by measuring the diameter of the trunk 4 inches above the bud union in July 1977.

Hurricane Beulah in September 1967, reduced the yield for that year.

Thirteen trees of each selection were planted in a 13 x 13 Latin Square. The fruit has been harvested each year in December or January. The fruit was sized 96's and larger and 112's and smaller for size evaluation.

RESULTS AND DISCUSSION

Fruit production for 10 years, and seventh through sixteenth orchard years, and cumulative yields for this period are presented in Table 1. Because of the wide range of yields that occurred between trees within each selection, it was often difficult to obtain statistical significance between selections even though average tree yields sometimes differed by more than 100 lb.

During the 10-year period of this report fruit production was greatly affected by the heavy pruning brought on by the greater vegetative growth of the 12 nucellar selections. Fruiting wood was always destroyed in this operation, and yields were reduced the first season that followed. By the second season after pruning, excellent yields were again obtained. Severe hedging on four sides plus topping in February 1975, caused the most drastic yield reduction; however, yields were among the highest recorded the next year. A similar situation occurred following the hedging in February 1968.

Less frequent hedging would have been required if the entire planting had been old-line trees. Thus, a consistently medium to low ranking of the old-line is not necessarily a good indication of the performance that should be expected under different conditions.

The differences between selections and their ranking each year and between years are remarkably evened out when cumulative yields are looked at on a ton/acre basis averaged over the 10 years (Table 1).

The nucellar Fawcett Red was consistently a poor yielder. This was undoubtedly due to its recent seedling origin and the fact that the frequent pruning each time returned the trees of this selection to the juvenile vegetative condition.

Fruit sizes were smaller most seasons on the old-line Ruby Red and the nucellar California Red No. 3 than on the highest ranking selections (Table 2). Size separations were 96's and larger and 112's and smaller.

Fruit size did not appear to be affected by heavy or light crops. Figure 1 shows yields and sizes of the old-line selection and one of the nucellar selections. It can be seen that in some years when production went up sizes were also up. The 1976 season was one of generally poor fruit size in the Valley although the exceptionally heavy crop may have suppressed the fruit size this season. Sizes were not measured in 1975 because of the very small amount of fruit produced.

Tree growth is reflected in trunk diameter measured in July 1977. The old-line Ruby Red had significantly less growth than all the nucellars. The nucellar

Table 1. Ranking of average yields of old-line Ruby Red and 12 nucellar red grapefruit selections through 10 seasons (seventh year through sixteenth). Trees planted in 1960.

Selection[x] - Yield in lb/tree[z]										Tons/acre[y]
1967	h 1968	1969	h 1970	1971	1972	h 1973	1974	ht 1975	1976	10 Year Ave.
A 314a	A 356a	F 654a	E 365a	C 487a	E 485a	G 355a	A 512a	M 150a	C 665a	A 20.4
F 295ab	G 336	L 651	A 360	A 486	A 480	A 323	J 424ab	C 60b	D 638	C 19.4
L 280	D 334	G 650	G 348ab	L 475	J 463	B 318	C 411	A 55	J 628ab	J 19.1
I 280	I 312ab	E 646	K 340	K 448	F 460	C 312	F 405	L 54	A 623	G 19.0
B 274	B 310	C 631	J 332	D 439	B 454	M 310	B 397	J 53	B 605	B 18.8
G 267	K 310	J 619	F 324	J 439	C 444ab	L 307	K 396ab	B 52	F 600	F 18.7
J 260	L 304	B 607	D 324	F 432	M 443	D 306	L 388b	E 44	I 592	D 18.5
C 259	J 303	D 600	C 322	G 430	K 442	J 302	M 382	F 42	G 590	E 18.5
D 247	M 302	K 591	M 321	I 425	G 439	I 289	E 376	K 36	E 590	L 18.5
E 245	E 298	I 584	B 319	B 421	D 426	F 289	I 371	G 35	L 590	K 18.0
M 240ab	C 285ab	H 574	I 318	E 397	I 417	K 264	D 360	D 30	K 566abc	I 18.0
K 206b	F 244bc	A 563a	H 284ab	M 380	L 392ab	H 253	G 357	H 18	M 529bc	M 17.0
H 123c	H 195c	M 352b	L 267b	H 377a	H 342b	E 247a	H 231b	I 10b	H 456c	H 14.3

[z] Means in each column spanned by the same letter are statistically alike, Duncan's m.r.t., 1% level.

[y] Based on 100 trees/acre, 22 x 20 ft spacing.

[x] A Nuc. Calif. Red No. 3
B Nuc. Redblush (RFR13T3)
C Nuc. Redblush (CCR24T2)
D Nuc. Redblush (CCR23T2)
E Nuc. Redblush (CCR22T5)
F Nuc. Redblush (CCR20T3)
G Nuc. Riddle Redgold
H Nuc. Fawcett Red
I Nuc. Shary Red
J Nuc. Langford Red No. 1
K Nuc. Curry Red Radiance
L Nuc. Ruby Red
M Old-line Ruby Red

[h] Hedged — Feb. 1968, 1970, 1973

[ht] Hedged and Topped — Feb. 1975

Table 2. Ranking of fruit size distribution at harvest time over eight seasons and tree trunk growth at 17 years after planting for old-line Ruby Red and 12 nucellar red grapefruit selections.

Selection[y] - % size 96+[z]								Trunk dia. (Inches) at 17 years
1968	1969	1970	1971	1972	1973	1974	1976	
H 72a	M 89a	L[y] 91a	J 92a	H 93a	F 94a	D 97a	F 80a	H 13.1a
C 71	D 87ab	C 83ab	E 91a	D 90ab	K 92	F 96	K 78	D 12.5ab
L 71	E 87	B 83	I 89ab	L 90	J 91	C 96	H 77a	F 12.3
F 69	F 87	I 82	H 89	B 89	H 91a	L 96	B 74ab	C 12.3
J 67	K 87	H 82	B 89	J 88	E 89ab	J 96	L 73	G 12.3
I 67	B 86	J 81	D 88	K 88	I 88	I 96	J 72	K 12.2
K 67	C 86	D 80	K 87	I 87	D 87	M 95	I 72	J 12.1
D 65	G 86	F 80	F 86	C 84	C 87	H 95	D 71	L 12.0
G 64	I 86	K 78ab	L 86	F 83	B 87	B 95	G 69ab	B 12.0ab
B 62ab	J 86	G 76b	C 85	G 80ab	M 86	K 95	C 66b	A 11.8b
E 62	L 86ab	M 73bc	M 83ab	A 78b	L 86ab	G 94	M 65b	I 11.7
M 57ab	H 85b	E 71bc	G 81b	M 77	G 82b	A 93	E 64bc	E 11.6b
A 42bc	A 85b	A 62c	A 80b	E 77b	A 81b	E 91a	A 55c	M 9.2c

[z] Means in each column spanned by the same letter are statistically alike, Duncan's m.r.t., 1% level.

[y] Based on 100 trees/acre, 22 x 20 ft spacing.

x
A Nuc. Calif. Red No. 3
B Nuc. Redblush (RFR13T3)
C Nuc. Redblush (CCR24T2)
D Nuc. Redblush (CCR23T2)
E Nuc. Redblush (CCR22T5)
F Nuc. Red blush (CCR20T3)
G Nuc. Riddle Redgold
H Nuc. Fawcett Red
I Nuc. Shary Red
J Nuc. Langford Red No. 1
K Nuc. Curry Red Radiance
L Nuc. Ruby Red
M Old-line Ruby Red

[h] Hedged — Feb. 1968, 1970, 1973

[ht] Hedged and Topped — Feb. 1975

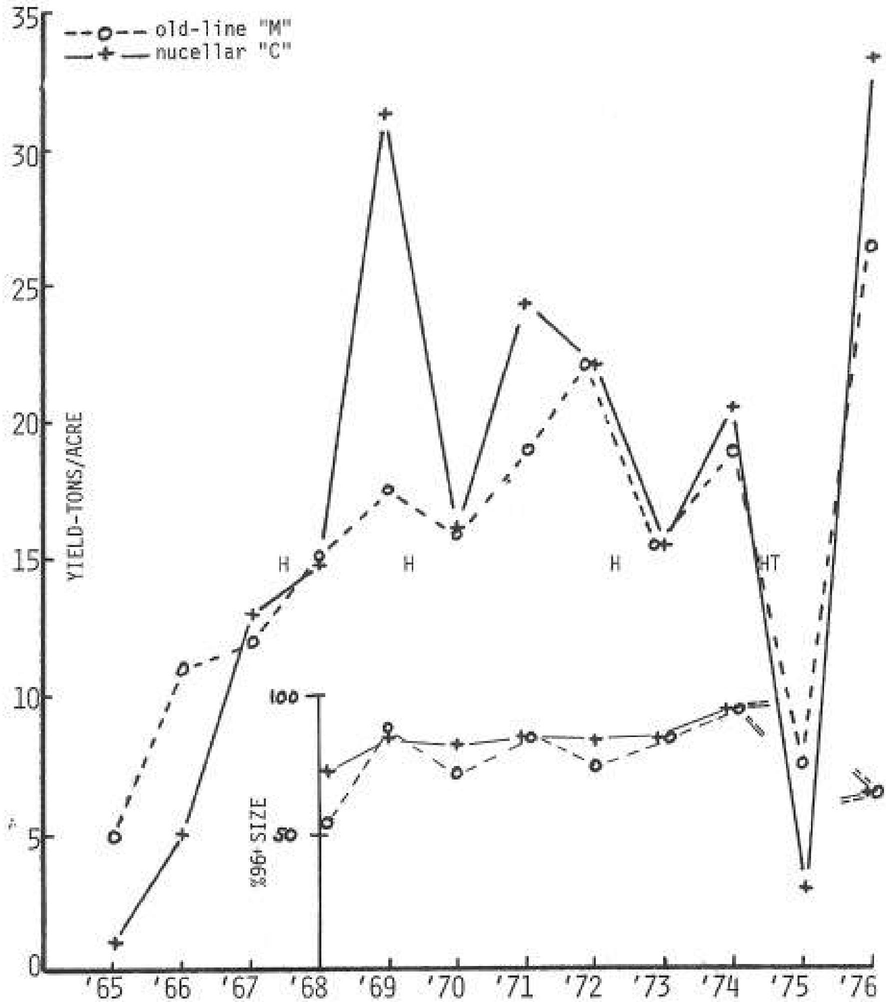

Fig. 1. Yields in tons/acre and % 96+ size of old-line Ruby Red "M" and one nucellar Redblush selection "C". Trees hedged (H) two sides Feb. 1968, 1970, and 1973, and hedged four sides and topped (HT) Feb. 1975.

Fawcett Red had the greatest growth, which again is consistent with its being a young nucellar line.

After 16 years, it can be concluded that nucellar red grapefruit in Texas will produce yields over a period of time that are equal to or greater than the old line.

Fruit sizes of the old-line and the nucellar California Red No. 3 can be expected to be smaller in some years than some nucellar selections.

No consistent fruit size and crop size relationship could be determined. It appears that fruit size may be affected more by season or orchard conditions than whether the crop is large or small.

Tree growth is greater with nucellar red grapefruit than old-line, even where the trees are many years away from their seedling parent. This vigorous growth soon crowds a planting requiring more frequent hedging than necessary with old-lines at the same spacing. Growth in height of nucellars is also greater than old-lines and this poses harvesting problems unless the trees can be kept topped to harvestable heights.

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Observations on Grapefruit Budded on Seedling or Cutting Rootstocks in a Closed-Spaced Planting

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ABSTRACT

One row of grapefruit trees budded on seedling rootstocks was planted 8 ft from another budded on cuttings. The trees were spaced 1, 2, 3, 4, and 6 ft within the row. Growth and yields/tree for the 1 and 2 ft spacings were considerably reduced, but yields/acre were high. The trees on the cutting rootstocks had much higher yields at all spacings than those on seedling rootstocks. While row position may explain some yield differences, other factors suggest the interaction of rootstock with spacing must also be involved.

Highly productive apple orchards using dwarfing rootstocks may have tree densities exceeding 800 trees/acre (11). Similar densities have been achieved with peach trees planted in hedgerows and severely pruned (9). These high density orchards generally produce earlier and yield more fruit than traditionally spaced orchards. Navel oranges on slightly dwarfing Rubidoux trifoliate rootstocks at 324 tree/acre had nearly twice the yield of a 134 tree/acre planting for the first five harvests (1). Rooted hardwood cuttings are commonly used for deciduous fruit tree rootstock but citrus rootstock are usually seedlings. Halma (6, 7) showed oranges on cuttings planted at wide spacings differed little from seedling rootstocks in fruit yield and growth. Since tree spacing has been reported to alter citrus root growth, the differences in origin and growth pattern between seedling and cutting rootstocks might be expected to cause dissimilar responses to close tree spacing (2, 8, 10). This paper offers some preliminary observations on the growth and yield of grapefruit trees budded on seedling or cutting rootstocks and planted at very close spacings.

PROCEDURE

In May 1971, rooted cuttings and seedlings of sour orange, *Citrus aurantium* L., were planted in two east-west rows 8 ft apart. Each row had a total of 40 cuttings or seedlings divided into five spacing treatments of eight trees each. The spacings and corresponding tree densities were: 1 ft, 5,445 trees/acre; 2 ft, 2,722 trees/acre; 3 ft, 1,815 trees/acre; 4 ft, 1,361 trees/acre; and 6 ft, 908 trees/acre. In August 1971, the stocks were budded in place with Ruby Red grapefruit, *Citrus paradisi* Macf. Because no more rooted cuttings were available, the additional replication required for a more complete experimental design was not possible. This limitation is accounted for in the interpretation of the yield and growth data presented.

In May 1974, the trunk diameters one inch above the bud union and the tree heights were measured. In March 1976, the tree canopy volumes were estimated using a standard tree with a 1-cubic yd canopy for comparison. The estimates, made independently be two evaluators, were averaged for each tree. The number and weight of fruit from individual trees within each spacing plot were recorded in the spring of 1976 and 1977.

RESULTS

After two years, competition between the trees in the 1, 2, and 3 ft spacing reduced trunk growth but not height (Table 1). There were no significant differences in trunk size or tree height between the seedling or cutting rootstocks. By 1976, trees in the 1 and 2 ft spacings had ½ to ⅔ the canopy volume of the 3, 4, 6 ft-spaced trees. Trees on cutting rootstocks appeared taller and more vigorous than the seedling rootstock trees, but this difference was not supported statistically. At this time, the canopies of trees in all spacings had completely closed the 8-ft space between the two rows of trees.

Table 1. Growth indices of Ruby Red grapefruit trees planted at five close spacings.

	Spacing (ft)				
	1	2	3	4	6
Trunk diameter (inch) May, 1974	1.34[z] a	1.58 ab	1.58 ab	1.77 bc	1.93 c
Tree height (ft) May, 1974	3.8	4.2	4.0	4.2	4.4
Canopy volume (cubic yd) Mar., 1976	1.5 a	1.9 a	2.7 b	3.1 bc	3.5 c

[z] Means separated by Duncan's multiple range test, 1% level.

Fruit yields/tree increased as the spacings increased, and for all spacings, the trees on rooted cuttings had much higher yields than the seedling rootstock trees (Table 2). Average weight/fruit from the trees on cuttings was also significantly higher than the trees on seedling rootstocks. While fruit size tended to increase with wider spacing, the trend was not consistent enough to be significant. With minor exceptions, average yields/tree in each spacing treatment were about the same for the two harvest seasons.

The average yields calculated in tons/acre were particularly high for the trees on cutting rootstocks (Table 3). The position of the row of cuttings, on the south side of the seedlings, might favor higher yields for these trees but differences of the magnitude shown in Table 3 must take into account other factors which are discussed below. Comparing Tables 1, 2, and 3 it is evident that in these young trees, growth, fruit production, and yields/acre are responding independently and disproportionately to the combined influences of close spacing and rootstock origin. For example, the fact that yields do not increase by the same ratio as tree populations decrease suggests that under intense competition grapefruit's productive capacity, like peaches, should be evaluated/unit of canopy or bearing surface (9).

Table 2. The number and average weight of fruit from Ruby Red grapefruit trees on seedling or cutting rootstocks planted at five close spacings.

Rootstock		Spacing (ft) 1	2	3	4	6	Rootstock means
Seedling[y]	Number[z]	3 a	3 a	7 ab	13 ab	18 b	9
	Lb/fruit	.87	.92	.81	.83	.94	.88
Cutting[y]	Number[z]	12 a	24 b	18 ab	27 b	55 c	27
	Lb/fruit	1.00	1.01	1.08	1.04	1.07	1.04

[z] Means separated by Duncan's multiple range test, 5% level.

[y] Values are means of the 1975-76 and 1976-77 seasons.

Table 3. Yields (tons/acre) of Ruby Red grapefruit trees on seedling and cutting rootstocks planted at five close spacings.

Rootstock	Spacing (ft) 1	2	3	4	6
Seedling	7.2[z]	2.6	5.3	7.4	9.4
Cutting	34.4[z]	33.0	18.0	19.2	26.3

[z] Yields = average of 1975-76 and 1976-77 seasons calculated from

$$\frac{\text{lb./tree x trees/acre}}{2{,}000}$$

DISCUSSION

The fact that all the trees on cutting rootstocks were in the row on the south side of the seedling rootstock trees provides an easy explanation for the cutting's superior yields. Not only did these trees receive more sunlight, but they shaded the row of seedling rootstock trees. This possiblility definitely needs to be examined, but it seems an inadequate explanation for yield differences as great as those measured. First, for over 60% of the major fruit and tree growth period, the sun is nearly directly overhead. From April through September there is little shade found on the north side of anything in south Texas. Second, the south row by serving as a windbreak should increase fruit set and yield for the trees in the north row. The north half of trees in east-west rows consistently bears more fruit than the south half (3). Finally, early and/or heavy fruiting tends to **reduce** vegetative growth and fruit size which was not the case for the trees on cutting rootstocks (1, 10). On the other hand, a cutting rooted from mature wood could be expected to induce earlier flowering and fruiting in its scion than a seedling would (5).

If the number of fruit/tree for each spacing treatment (Table 2) is divided by the tree's estimated canopy volume, with one exception, the seedling rootstock trees have a value of around three fruit/cubic yd and the cutting rootstocks trees, 10 fruit/cubic yd. This supports the idea that under intense competition grapefruit trees produce a given amount of fruit/unit of-canopy regardless of tree spacing or density. Recongnizing the provisional nature of these results, it appears citrus budded on rooted cuttings and planted at close spacings have sufficient potential for early, high production to justify further research in this area.

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Orchard and Packinghouse Incidence of Grade-Reducing Blemishes in Texas Grapefruit

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ABSTRACT

A grapefruit blemish survey of 10 orchards and 10 packinghouses in the Rio Grande Valley was conducted in 1976-77. Windscar was the leading blemish in both orchard and packinghouse. Rust mite and melanose damage followed in severity in the orchard, with rust mite more prevalent in western orchards. The major packinghouse blemishes after scar in severity were speck melanose, rust mite russeting, rust mite buckskinning, greening, and mudcake melanose.

A number of external fruit blemishes cause considerable loss in packing grapefruit in the Lower Rio Grande Valley. More reliable figures on the incidence of grapefruit blemishes could have several beneficial results: 1) growers could protect and market their crops more knowledgeably; 2) handlers could strategically pack for the no. 2 market; 3) consumers through education could choose an appropriate grade for their situation; and 4) the researchers would be guided to areas of greatest need for work.

PROCEDURE

A pilot survey of 10 orchards and 10 packinghouses throughout the Valley was conducted. The 10 orchards were surveyed December-Janaury, 1976-1977. These were being used in a pest management study, making management information readily available. The locations of these orchards represent most Valley growing areas and are designated by numbers one through ten (Fig. 1). A random sample of 25 trees from each orchard was visually scored by tree from 0-10 for five blemish types : 1) windscar; 2) rust mite russeting; 3) rust mite buckskinning; 4) speck melanose; and 5) mudcake melanose. A tree score of "10" meant that 100% of the fruit in a tree would be out of U.S. no. 1 grade due to the blemish being scored, with "9" being 90% out of grade, etc. For each blemish, an adjusted single-tree observation was: percent fruit degraded per tree/25; the sum of 25 such observations gave a composite percent for a single blemish and was used as an estimate for the entire orchard.

The packinghouse survey was concerned only with the relative proportion of all identifiable blemishes which caused downgrading of fruit to U.S. no. 2. No attempt was made to relate these to the total fruit harvested. For identification of blemishes, a number of published sources were consulted, as were staff members of the Texas A&I Citrus Center and the Texas State Inspection Service (2,3,5,6). A sample of 100 fruit was examined in each house on each date from the no. 2 packing bin. All significant blemishes were recorded by fruit without regard to severity. Where two blemishes occurred on one fruit, each was tallied as one-half blemish. Seven houses were sampled twice, once in the November-January period (mid-season) and again in the first part of April (late-season); an eighth house was sampled three times, twice mid and once late; a ninth house was sampled mid-season only and a tenth late only. The 10 mid-season and nine late-season house samplings were combined into mid and late random pools respectively with blemish as the second factor of a two-way analysis of variance. A separate "T" test was run on blemish incidence comparing mid- to late-season samplings by blemish in an unpaired analysis with houses again pooled for the error term. Houses were pooled in both analyses because 1) nothing subject to management was singled out in the observations and 2) the origin of the fruit was unknown in most cases. Twenty-five blemishes were recorded through the season; 13 blemishes which showed at least 1% incidence through the season were chosen for analysis.

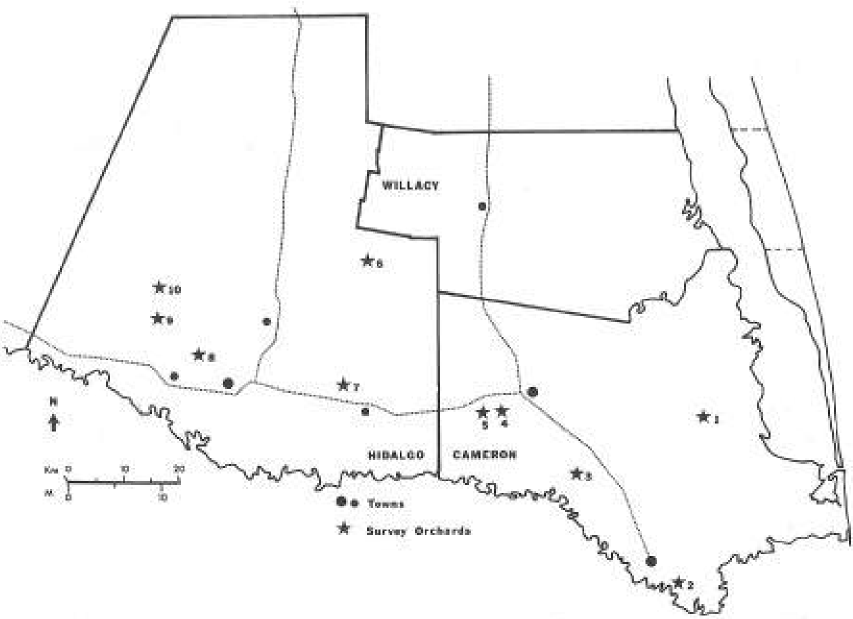

Fig. 1. The locations of test orchards for a survey of grapefruit blemishes in the Lower Rio Grande Valley. Stars locate the 10 orchards and are numbered from east to west. Circles are major towns, from east to west: Brownsville, Harlingen, Raymondville, Weslaco, Edinburg, McAllen, and Mission.

RESULTS

A. **Orchard survey** — Looking at blemish means, scar leads in severity, with rust mite and melanose damage second and third, respectively (Table 1). Interestingly, rust mite damage is predominantly of the mild russeting type, whereas melanose damage is predominantly of the severe mudcake type. Excluding orchards two and five, blemish severity tended to increase from the eastern to western end of the Valley. The rust mite incidence in orchards eight, nine, and ten contributed conspicuously to this effect. Since blemish was observed in orchard two after most of the fruit was picked, the high value must be questioned. The significant interaction between orchard and blemish means is expressed by: 1) the high rust mite damage in orchards eight, nine, and ten; 2) melanose damage being concentrated in orchards two, five, and six; and 3) wind scar being more evenly distributed among orchards.

B. **Packinghouse survey** — The incidence of blemishes in the packinghouse follows the pattern in the orchard except for mudcake melanose (Table 2). That might be explained by the low tolerance for mudcake melanose in the U.S.D.A. Grade Standards: none for U.S. no. 1 and 1-inch D for a 70 size U.S. no. 2 (7). Therefore most mudcake is graded out before it reaches the no. 2 packing bins. Scar again predominates as the no. one blemish with a mean of 44%, several times the incidence of russeting and speck melanose, second and third in severity, respectively. The remaining 10 blemishes comprise two broadly overlapping classes according to Duncan's test at the 5% level. Means of these two classes

Table 1. Blemishes occurring in 10 grapefruit orchards in the Rio Grande Valley during the 1976-1977 season.

	Percent degraded from 25 trees					
		Rust mite		Melanose		
Orchard	Scar	Russet	Buckskin	Speck melanose	Mudcake melanose	Orchard Mean[z]
1	13.6	0.0	0.0	0.8	0.0	2.8a
2	28.8	28.0	0.0	23.2	33.2	22.6d
3	14.0	0.8	0.0	0.0	0.0	2.9a
4	13.2	13.2	5.6	7.6	4.4	8.8b
5	8.8	5.6	3.2	2.4	53.2	14.6c
6	24.0	3.2	0.0	19.2	0.0	9.2b
7	9.6	20.0	0.0	5.2	0.0	6.9b
8	12.0	20.0	16.4	4.0	0.8	10.6b
9	10.8	14.0	22.4	0.0	0.4	9.5b
10	33.5	34.0	45.2	1.2	2.4	23.3d
Blemish mean	16.8d	13.9c	9.3b	6.36a	9.44b	

[z] Means without a common letter are significantly different at the 5% level of confidence, according to Duncan's multiple range test.

average 2.2 and 3.6%. A significant interaction was expressed in the comparisons of mid-season to late-season means. Of the pairs of means with significant "T" values, off-shape was predominant mid-season; black spot, puffy, rough, sunken black spot, and buckskin predominated in the late season. The total incidence for these six blemishes was 5.1 and 24.7% in mid- and late seasons, respectively.

Table 2. Grapefruit blemishes occuring in samples from 10 packinghouses in each of mid and late season, ten and nine 100-fruit samples respectively.

Blemish	Percent Blemish Mid	Late	"T"[z]	Blemish Mean[y]
Black spot	0.0	2.1	*	1.0a
Puffy	0.0	2.3	†	1.1a
Mishappen	2.2	0.0	**	1.2a
Sooty mold	1.5	0.9		1.2a
Rough	0.8	3.6	†	2.1ab
Thorn scratch	3.0	1.2		2.1ab
Sunken black spot	0.0	5.6	**	2.6ab
Mudcake melanose	4.7	0.6		2.7ab
Green	4.2	7.2		5.6ab
Buckskin, rust mite	2.1	11.1	**	6.4bc
Russeting, rust mite	12.8	8.0		10.5cd
Speck melanose	14.2	13.3		13.8d
Wind scar	49.0	41.1		43.6e

[z] "T" test: † Means differ at the 6% confidence level.
* Means differ at the 5% confidence level.
** Means differ at the 1% confidence level.

[y] Blemish means without a common letter are significantly different at the 5% confidence level, according to Duncan's multiple range test.

DISCUSSION

Wind scar supported its reputation of being the Valley's primary fruit blemish. The consistently high incidence of scar puts an imperative role on the control of rust mite and melanose. For example, orchards one, three, and four all had similar wind scar, but total blemish goes from 14.6% in orchards one and three to 44% in orchard four where rust mite and melanose were only partially controlled. A severe outbreak of one or more pests plus a high incidence of scar can lead to near total loss of no. 1 fruit, exemplified in orchard 10. Severe wind scar combined with two severe pest effects resulted in 100% degrading blemish.

Since all orchards received three and some as many as five sprays, including recommended acaricides, unique problems in controlling rust mite may be emerging. If developments in conventional chemical spray technology fail to alleviate rust mite damage, other solutions should be explored. Biological control is being actively pursued. An integrated effort at producing, packing, and marketing the U.S. no. 1 Bronze grade could reduce economic losses from russeting, the late season damage by rust mite.

The geographic pattern of rust mite damage in the present survey appears reversed from patterns indicated in a previous study which showed heavier rust mite infestations in the eastern portions of the Valley (4). In the present study, the western orchards, 7 to 10 incurred total rust mite damage of 20% to 80% compared to practically no damage for the eastern orchards, one and three, even though similar spray programs were used. Corroboration of the present pattern is reported by French (1).

In the packinghouse survey, certain apparently minor blemishes add up to almost 25% of late but only 5.1% of mid-season blemishes. Orchards heavy with buckskin were probably bypassed in early fruit buying, so buckskin fruit predominated in later pickings. However, puffiness, black spot and sunken black spot seemed to appear spontaneously from March on. The spotting blemishes were the subject of another study which will be reported separately. Since, except for speck melanose, the blemishes followed the same order of severity in the packinghouse and in the orchard, these studies tend to be mutually supportive. A larger, more systematic orchard sampling would help pinpoint geographical and management effects, particularly if the fruit was followed through a packinghouse without losing the orchard identity.

ACKNOWLEDGEMENTS

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A Comparison of Cash Flow Between Orchard Equipment Ownership and Hired Grove Care

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ABSTRACT

Orchard equipment investments can be analyzed using a cash flow analysis. Cash flow predicts the timing and magnitude of cash shortages and surpluses and reveals financial and income tax effects. The 50-acre orchard example shows income tax savings from an equipment investment occuring only in the first year as a direct result of investment credit and additional first-year depreciation. The equipment investment provides a better return than a savings account but a lower return than hired orchard care over the 10-year period of analysis.

This paper develops a methodology helpful in evaluating economic variables important in buying orchard equipment. The importance and effects of financing, cash flow, and income tax considerations are illustrated using a 50-acre orchard. A comparison is made between "do it yourself" orchard care and hired orchard care.

Orchard size presents a problem to growers providing their own orchard care. Cash outlays and large fixed machinery costs/acre are prohibitive for most small growers. But, with rising orchard care expenses, many growers are considering machinery purchases for specific orchard jobs. Owners would do the repetitive jobs, i.e., cultivation, that requires minimal cash outlays for equipment and leave the expensive insecticide machinery to orchard care companies. The grower considering an equipment investment should analyze the effects of cash flow over the life of equipment. Cash flow analyzes the inflow and outflow of dollars: inflow from increased income, reduced cash expenses, and income taxes; outflow to loan payment, interest, increased income taxes, and cash expenditures to maintain the investment.

Depreciation on the equipment does not affect cash flow since this is a non-cash expense. Depreciation is a deductable expense for income tax purposes, and the income tax savings resulting from depreciation affects cash flow. Interest on the owner's capital used in the investment likewise does not affect cash flow. Interest payments on a bank loan are part of the cash flow analysis.

Cash flow analysis looks primarily at the investment's ability to meet its financial obligations. A favorable cash flow occurs in an investment with low initial costs and low annual out-of-pocket cash expenses. Emphasis is placed on determining time periods of money shortages and surpluses.

Cash flow analysis allows use of income tax effects resulting from the investment. Investment credit and first-year depreciation claimed for income tax purposes can bring substantial income tax savings the first year of the investment.

ANALYSIS OF AN ORCHARD MACHINERY INVESTMENT

Assume that an owner of 50 acres of citrus is interested in providing complete orchard care. Gross income has been about $27,500 annually for the last few years. Total annual grove care expenses are $15,900. He originally paid 20% down on a $75,000 orchard and 6% interest/year on the declining balance. The orchard is now in the sixth year of a 10-year note.

The grower is contemplating a $25,000 investment in machinery. He does not expect an increase in gross income but, a reduction in annual operating expenses from doing his own grove care. With this equipment, he projects annual cash expenses at $13,100. Annual property taxes remain at $750. Insurance on the machinery costs $190/acre.

The important variables to consider in financing the equipment investment are downpayment, interest rate, length of note, payment interval, and method of interest computation. In this analysis, we assume a 20% downpayment and a 9% simple interest rate on the declining balance paid annually on a 5-year note with equal annual principle payments. Table 1 presents the annual cash flow for the first 10 years of the investment.

The grower should consider this pattern of cash flow over the life of the equipment investment. Net cash flow in the first year of use is severely restricted; a shortage continues through the fifth year when the equipment and orchard notes are paid out. Cash flow increases sharply to $13,460 in the sixth year and continues at this level through the tenth year, with a total over the 10-year period of $68,800 (Table 1).

INCOME TAX EFFECTS ON CASH FLOW

The feasibility of an investment can be improved by income tax considerations, primarily depreciation and investment credit. There are two types of depreciation:

1. Additional first-year depreciation — 20% of the cost of new or used equipment purchased during the year can be deducted in addition to regular depreciation. The limitation is 20% of $10,000 on a single return or $20,000 on a joint return on all qualifying property purchased during the year.

Table. 1. Annual cash flow with equipment investment.

Year	Income	Annual cash expenses	Loan payment machinery	Interest payment machinery	Loan payment orchard	Interest payment orchard	Net cash flow
Downpayment			$ 5,000				-$ 5,000
1	$ 27,500	$ 14,040	4,000	$1,800	$ 6,000	$1,800	- 140
2	27,500	14,040	4,000	1,440	6,000	1,440	580
3	27,500	14,040	4,000	1,080	6,000	1,080	1,300
4	27,500	14,040	4,000	720	6,000	720	2,020
5	27,500	14,040	4,000	360	6,000	360	2,740
6	27,500	14,040	0	0	0	0	13,460
7	27,500	14,040	0	0	0	0	13,460
8	27,500	14,040	0	0	0	0	13,460
9	27,500	14,040	0	0	0	0	13,460
10	27,500	14,040	0	0	0	0	13.460
Total	$275,000	$140,400	$25,000	$5,400	$30,000	$5,400	$68,800

Table 2. Care by owner cash flow with income tax effect.

Year	Orchard income	Annual cash expenses	Loan payment mach.	Interest payment mach.	Loan payment orchard	Interest payment orchard	Deprecia-tion mach.	Deprecia-tion trees	Taxable income (-Loss)	Income tax (+Savings)	Net cash Flow
Downpayment			$ 5,000								-$ 5,000
1	$ 27,500	$ 14,040	4,000	$1,800	$ 6,000	$1,800	$ 8,200	$ 5,000	-$ 3,340	$ 3,502	3,362
2	27,500	14,040	4,000	1,440	6,000	1,440	3,360	5,000	2,220	-666	-86
3	27,500	14,040	4,000	1,080	6,000	1,080	2,688	5,000	3,612	-1,084	216
4	27,500	14,040	4,000	720	6,000	720	2,150	5,000	4,870	-1,461	559
5	27,500	14,040	4,000	360	6,000	360	1,720	5,000	6,020	-1,806	934
6	27,500	14,040	0	0	0	0	1,376	0	12,084	-3,625	9,835
7	27,500	14,040	0	0	0	0	1,101	0	12,359	-3,708	9,752
8	27,500	14,040	0	0	0	0	881	0	12,579	-3,774	9,686
9	27,500	14,040	0	0	0	0	705	0	12,755	-3,827	9,633
10	27,500	14,040	0	0	0	0	564	0	12,896	-3,869	9,591
Total	$275,000	$140,400	$25,000	$5,400	$30,000	$5,400	$22,754	$25,000	$76,055	-$20,318	$48,482

2. Regular depreciation — This is determined by the depreciation basis, the useful life and method of computation (double declining balance in this example). The depreciation basis must be reduced by the additional first-year depreciation before regular depreciation is calculated.

Investment credit is a tax credit applied directly against income tax. Property qualifies if it is depreciable, has a life of at least three years, is tangible personal property and is placed in service in the taxable year.

The amount of investment credit depends on the declared useful life of the investment. Full credit, 10%, is available for investments with a useful life of seven years or more; ⅔ of the credit for a useful life between five and seven years, and ⅓ of the credit for a useful life between three and five years. There are also limitation on investment credit; $12,500 for a single return and $25,000 for a joint return. In the example, investment credit is $2,500 or 10% of the equipment cost.

The income tax effects on the grower's investment (Table 2) are calculated by the equation:

$ITS_i = IC_i + (OI_i - ACE_i - MD_i - TD_i - IMP_i - IL_i)\ MTR.$

where, i = number of years, i.e., $i = 1,2,3,\ldots,10$

ITS_i = income tax savings in the ith year

IC_i = investment credit, applicable only in the taxable year the property is placed in service, zero elsewhere.

OI_i = orchard income in the ith year.

ACE_i = annual cash expenses in the ith year

MD_i = machinery depreciation in the ith year

TD_i = tree depreciation in the ith year, the example starts in the sixth year from date of purchase of orchard.

IMP_i = interest payment on machinery in the ith year

IL_i = interest on land payment in the ith year

MTR = marginal tax rate; example assumes 30% rate

For year 1,

$ITS_1 = \$2,500 + (\$27,500 - \$14,040 - \$8,200 - \$5,000 - \$1,800 - \$1,800).30 = \$3,502$

For year 2,

$ITS_2 = 0 + (\$27,500 - \$14,040 - \$3,360 - \$5,000 - \$1,440 - \$1,440).30 = \$666$

The net cash flow for any year is defined by the equation:

$NCF_i = (OI_i + ITS_i) - (MLP + LLP + IMP_i + IL_i + ACE_i)$ where,

i = number of years, i.e., $i = 1,2,3,\ldots,10$

NCF_i = net cash flow in the ith year

OI_i = orchard income in the ith year

ITS_i = income tax savings in the ith year

MLP = loan principal payment on machinery

LLP = loan principal payment on orchard

IMP_i = interest payment on machinery in the ith year
IL_i = interest payment on land in the ith year
ACE_i = annual cash expenses in the ith year

For year 1,

$$NCF_1 = (\$27{,}500+\$3{,}502)-(\$4{,}000+\$6{,}000+\$1{,}800+\$1{,}800+\$14{,}040) = \$3{,}362$$

For year 2,

$$NCF_2 = (\$27{,}500-\$616)-(\$4{,}000+\$6{,}000+\$1{,}440+\$1{,}440+\$14{,}040) = -\$86$$

Income tax considerations reduce the total net cash flow by $20,318 ($68,800 before taxes and $48,482 after taxes). The first year of the investment provides a $3,502 tax savings which is a direct result of investment credit and additional first-year depreciation. The 2nd through tenth year's tax effects follow the magnitude of the grower's net cash flow.

Cash flow analysis needs to be carried one step further. The analysis is conducted over 10 years assuming a constant dollar value. The net cash flow needs to be adjusted to reflect that a dollar today is worth more than a dollar tomorrow or 10 years from now. This is called the present value of the investment in today's dollars, and can be determined by the equation:

$$CNPV = \sum_{i=1}^{10} \frac{NCF_i}{(1+r)^n}, \text{ where } i=1,2,3,\ldots,10 \text{ and}$$

CNPV = cumulative net present value
r = rate of interest or discount rate
n = number of years
NCF_i = net cash flow for the ith year

Computation of present value depends upon determination of an appropriate rate of interest. It is best to use an interest rate obtainable from a relatively "risk-free" investment such as some type of savings account.

Each year's net cash flow is discounted to determine its present value. Adding each year's present value yields the cumulative net present value for the investment. If the yearly present value figure is positive, then it provides a greater return than the savings account.

The present value analysis allows the investment with its futuristic and often uneven yearly cash flow to be viewed in today's dollars and provides a common base to analyze alternative investments. For the example we assumed a 9% compounded interest rate which yields a 6.3% after-tax rate assuming the 30% marginal tax rate.

Table 5 shows the present value of the machinery investment for 10 years with a 6.3% rate of interest. The net cash flow (Table 2) indicates a balance of $48,482 after 10 years assuming no interest on the accumulated balance. The present value of this cash flow over 10 years is $29,325. Since this net present value is positive, the after tax rate of return on the grower's capital investment is greater than the 6.3% compounded interest rate he would have received if he had invested in a savings account. Note, however, that the cumulative net present value is not positive until the sixth year of use. Overall this indicates a profitable investment. The problem faced is a cash drain on his outside income for the first five years of the investment.

A COMPARISON OF CASH FLOWS UNDER HIRED GROVE CARE AND CARE BY OWNER MANAGEMENT

An analysis of the investment must consider the economic situation facing the grower today. Being a better investment than a savings account does not imply that the investment is more profitable than his current method of orchard care. Originally, we stated that the grower was becoming dissatisfied with his orchard care expenses. He believed an investment in equipment would reduce his annual expenses and improve his cash flow. To compare the investment to his present management system, a cash flow was developed for a hired orchard care management program (Table 3). The same level of gross income, orchard land repayment and tree depreciation is employed. The annual cash expenses are $15,900/year.

The total net cash flow over the 10-year period is $54,920. There is not an income tax savings in any year. The net cash flow is reduced only by the orchard principal and interest payment. In year six, the net cash flow increases substantially and remains at this level for the remaining years of the analysis.

A comparison of the two management systems shows the accumulated net cash flow of hired orchard care to be $6,438 greater than the care by owner method (Table 4). Present values differ by $7,598 in the same direction (Table 5). The difference is due to the larger initial cash drain resulting from the equipment purchase. Even though the investment yields higher positive returns in years 6-10 than hired orchard care, the value of this later stream of income in today's dollars cannot offset the initial cash deficit encountered in the first five years.

The equipment investment, although providing a better return than a savings account, does not improve the orchard owner's financial position, i.e., $36,933 grove care cumulative net present value is greater than $29,325 care by owner net present value after the equipment investment. In addition, the orchard owner may well find himself in a severe cash flow bind in the first five years. At this point it would be wise to postpone the equipment investment until the orchard is paid off or seek a longer repayment period on the equipment loan.

The example presented indicates how cash flow analysis can provide a clear view of financial and income tax effects. It predicts timing and magnitude of cash shortages and surpluses. It will handle uneven cash income and expenses and investments staggered over various acquisition stages.

Table 3. Hired orchard care cash flow with income tax effect.

Year	Income	Annual cash expenses	Loan payment orchard	Interest payment orchard	Depreciation trees	Taxable income (-Loss)	Income tax (+Savings)	Net cash flow
1	27,500	15,900	6,000	1,800	5,000	4,800	-1,440	2,360
2	27,500	15,900	6,000	1,440	5,000	5,160	-1,548	2,612
3	27,500	15,900	6,000	1,080	5,000	5,520	-1,656	2,864
4	27,500	15,900	6,000	720	5,000	5,880	-1,764	3,116
5	27,500	15,900	6,000	360	5,000	6,240	-1,872	3,368
6	27,500	15,900	0	0	0	11,600	-3,480	8,120
7	27,500	15,900	0	0	0	11,600	-3,480	8,120
8	27,500	15,900	0	0	0	11,600	-3,480	8,120
9	27,500	15,900	0	0	0	11,600	-3,480	8,120
10	27,500	15,900	0	0	0	11,600	-3,480	8,120
Total	$275,000	$159,000	$30,000	$5,400	$25,000	$85,600	-$25,680	$54,920

Table 4. Cash flow change from the equipment investment.

Increased Cash Flow	
1. Reduction in hired orchard care costs ($159,000-$140,400)	$18,600
2. Investment credit	2,500
3. Reduced Income tax ($85,600-$76,055).3	2,862
	$23,962
Decreased Cash Flow	
1. Equipment purchase	$25,000
2. Interest on equipment note	5,400
	$30,400
Cash flow change from equipment investment	-$6,438

Table 5. Present value analysis of hired orchard care and care by owner.

Year	Hired Orchard Care: Net cash flow	Hired Orchard Care: Discounted cash flow	Hired Orchard Care: Cumulative net present value	Care by Owner: Net cash flow	Care by Owner: Discounted cash flow	Care by Owner: Cumulative net present value
Downpayment				-5,000	-5,000	-5,000
1	$ 2,360	$ 2,220	$ 2,220	$ 3,362	$ 3,163	-$ 1,837
2	2,162	2,332	2,332	-86	-77	-1,914
3	2,864	2,387	6,939	216	180	-1,734
4	3,116	2,454	9,393	559	440	-1,290
5	3,368	2,495	11,888	934	692	-602
6	8,120	5,639	17,527	9,835	6,830	6,228
7	8,120	5,307	22,834	9,752	6,374	12,602
8	8,120	4,982	27,816	9,686	5,942	18,544
9	8,120	4,694	32,510	9,633	5,568	24,112
10	8,120	4,413	36,923	9,591	5,213	29,325
Total	$54,920	$36,923	$36,923	$48,482	$29,325	$29,325

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Seasonal Price Patterns of Texas Citrus

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ABSTRACT

Recurring seasonal factors influence weekly Texas citrus prices to create systematic patterns. Results indicate that grapefruit and early mid-season orange FOB prices are highest in October and lowest in January. Valencia FOB prices are highest in March and lowest in May. Grapefruit prices show a definite inverse price/quantity shipped relationship. Early-midseason and Valencia orange shipments do not coincide with their lowest FOB prices. Early-midseason orange shipments are affected by pre-Christmas sales whereas Valencia shipments are heaviest in March when early-midseason orange shipments are finished.

Most agricultural commodities have seasonal price fluctuations associated with yearly production patterns. These price fluctuations are inversely related to the commodity's supply. Texas citrus exhibits this inverse relationship; FOB prices are higher and more variable early and late in the season when the supply of marketable fruit is limited. Midseason volume of saleable fruit is large and prices are depressed.

Historically, increased exports and greater processing have altered this price movement; however, the basic pattern is still very apparent. The pattern is shaped by such factors as fruit quality, quantity, and the marketing system. Fruit growth, maturity, and weather indirectly affect price by influencing the volume of marketable fruit. On the other hand, early season Texas citrus prices often reflect the level of competition and supplies of citrus and deciduous fruit from other areas.

PROCEDURE

Seasonal weekly weighted FOB price indices of grapefruit, early-midseason and Valencia oranges were calculated for a 350-week period from 1965 through 1976, excluding the 1968-69 season. FOB prices for grades (no. 1, no. 2, and combination) are for a 254-week period 1969-70 through 1975-76. All data comes from the Texas Valley Citrus Committee "Citrus Segments" reports.

The statistical method used adjusted for trend and cyclical influences (7). The method involved: 1) detrending price data; 2) computing a centered moving average for 35 weeks or 22 weeks, depending upon variety; 3) developing an index, the average price of each week expressed as a percent of the moving average; 4) calculating the mean of the percentages obtained for any given week for the selected number of years and the standard deviations of the percentages. The original weekly price for any week includes seasonal variation. The centered moving average percentage (step 3) measures the weekly fluctuations in price due to seasonal variation. Any of these weekly indices represents the ratio of the weekly price to the season's average price expressed as a percent.

The weekly price index with its associated standard deviation is shown in Fig. 1. The shaded area represents one standard deviation from the curve of weekly price indices. Statistically, there is a ⅔ chance that the weekly price index will fall within the shaded area. The width of the shaded area indicates the consistency of the price pattern, i.e., the narrower the band the more consistent the price pattern.

Seasonal grapefruit prices — grapefruit accounted for 62% of all citrus harvested in Texas' 1976-77 season. Of the 23,000 carlot equivalents produced, 8,688 went domestic, 2,238 to export, and 11,390 to processing. Texas shipments were 25.7% of the total U.S. fresh grapefruit movement from October through May 1976-77. Florida's share of the market was 64.3% and Arizona-California's 10%.

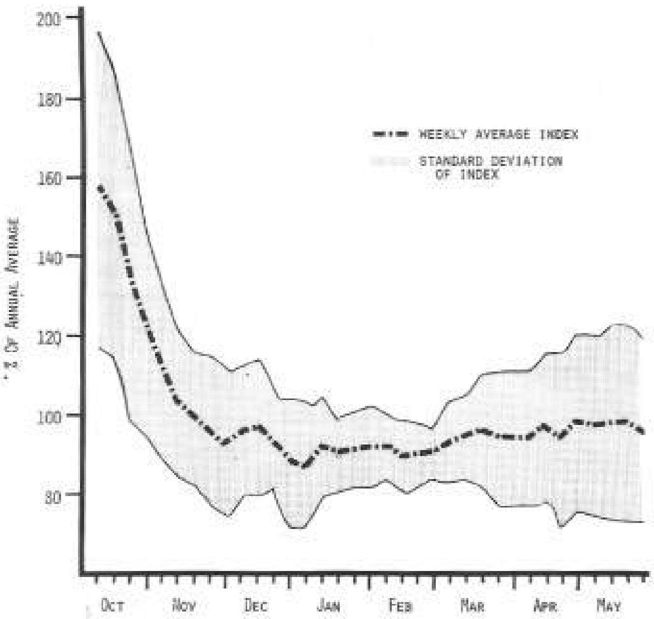

Fig. 1. Index of seasonal fob price variations: grapefruit no. 1 and no. 2 grades.

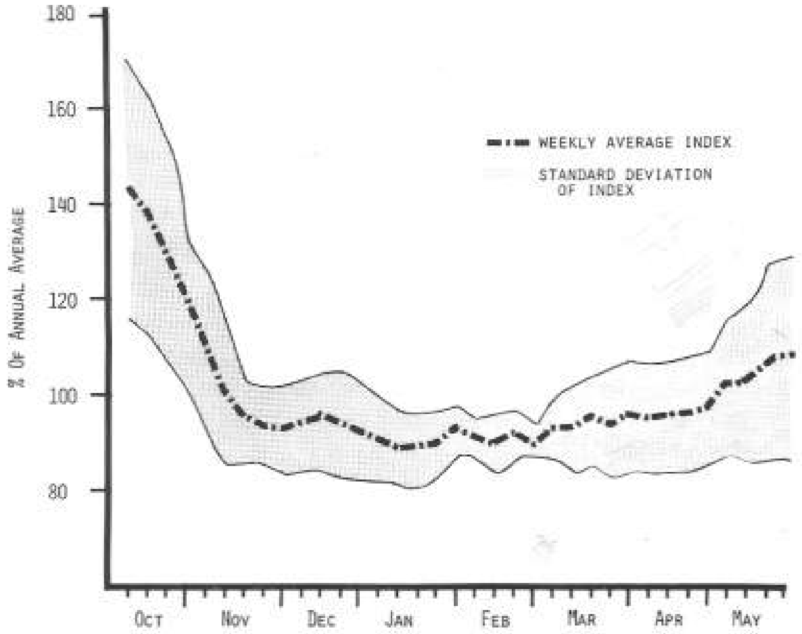

Fig. 2. Index of seasonal fob price variations: grapefruit no. 1 grade.

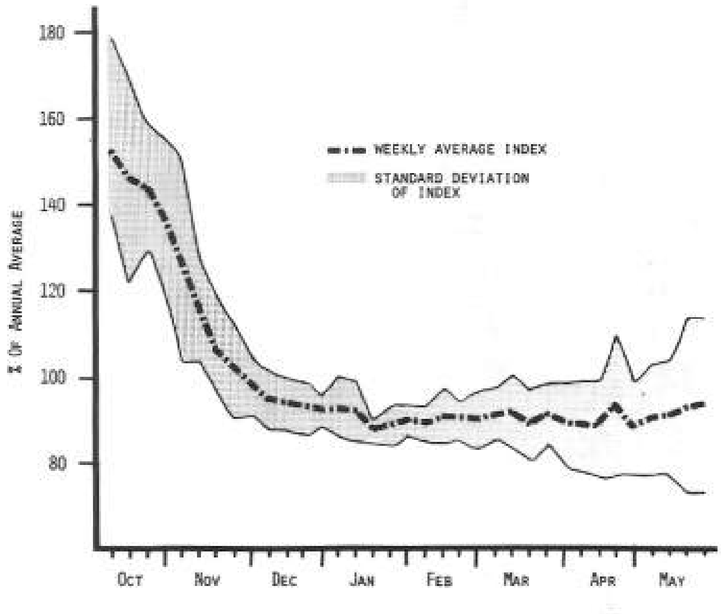

Fig. 3. Index of seasonal fob price variations: grapefruit no. 2 grade.

Texas' production has increased tenfold since the 1962 freeze. In the 1963-64 season production was only 2,000 cars (3). This recovery has provided a supply of grapefruit sufficient for Texas' extablished markets and is reflected in the FOB prices.

FOB prices have trended only slightly upward since the 1962 freeze. The increase has been $.0037/carton/week since 1965; $.004/carton/week since 1969. Seasonally, FOB prices are highest in October and lowest in February with a 70% spread between the highest October weekly index and the lowest February index (Fig. 1).

The inverse price/supply relationship is evident from the weekly average grapefruit shipments (Table 1). Shipments are lowest in October (91 cars/week) and highest in February (408 cars/week). Since these shipments coincide with the highest and lowest weekly indices, grapefruit shipments would definitely appear to influence weekly FOB prices.

Table 1: Average weekly grapefruit shipments by moths months by grades.

Month	Cars			Percent	
	No. 1	No. 2	Total	No. 1	No. 2
Oct.	70	21	91	77	23
Nov.	182	79	261	70	30
Dec.	256	107	363	71	29
Jan.	228	144	372	61	39
Feb.	248	160	408	61	39
Mar.	191	120	311	61	39
Apr.	146	89	235	62	38
May	69	38	107	64	36

Seasonal price patterns have stabilized over the last 10 years. Average weekly variation declined by 11% in October, 5% in January, 1% in February, and 7% in May when the last six years are compared with the last 10 years. This increased stability has resulted from the improved availability of marketable fresh grapefruit since the 1962 freeze. A steady supply of fruit tends to stabilize domestic markets, providing a base for an improved marketing effort.

The affect of grade on the weighted FOB price should be apparent if the indices for no. 1's and no. 2's are analyzed separately then compared with the weighted FOB index (Figs. 2, 3). However, neither grade seems to exert a disproportionate influence on the weighted price. Average October weekly variability is 22% for no. 1's and 21% for no. 2's. This small difference between grades is consistent throughout the season, as is the lower price level of no. 2's compared with no. 1's.

The similarity in variability between the no. 1 and no. 2 grades runs counter to expectation. Being an inferior product, no. 2's should generate more bargaining with a resultant wide price variation. Instead, the variation suggests a market as consistent as that for no. 1 fruit. Apparently the no. 2 fruit is not considered an inferior product but only faces a more limited market demand and returns a much smaller profit margin to the shipper.

These statements are substantiated by the no. 2 packout for the last five years. Between October and December, no. 2 packout is 23% to 30% of the fruit shipped. After Christmas no. 2 packout increases to 39% for January, February, and March, then slips to 38% in April and 36% in May. These volumes represent rather consistent month to month shipments of no. 2 fruit, a consistency not anticipated in the heaviest volume months of the year (Table 1).

The actual price level/carton of the no. 2 grade, before and after Christmas, is consistently lower than the no. 1 grade. Since it costs approximately the same to pack no. 2's as no. 1's the lower price/carton gives the shippers a smaller profit margin on no. 2's. A narrow profit margin forces no. 2's into processing when market prices fall below the level required to pack the no. 2 grade.

Seasonal early-midseason orange prices — early-midseason oranges accounted for 23% of Texas citrus harvested in the 1976-77 season. This is 8,106 carlot equivalents; 3,362 cars to the fresh market, 26 cars exported, and 4,718 cars processed. Texas shipped 8.3% of the fresh oranges used in the U.S. during this October-February marketing period, while Florida shipped 28.5% and Arizona-California 63.2%.

Texas orange production, like grapefruit, has recovered from the 1962 freeze. Texas produced 480 cars of all orange varieties in 1963-64 season (3). Production increased to 15,600 cars in the 1972-73 season and then declined. The 1976-77 estimate is slightly more than 12,618 cars. The 1980-81 estimate for orange production is 10,875 cars (1).

Early-midseason FOB prices are highest in October and lowest in January (Fig. 4).There is a 32% difference between the October high and the January low. FOB prices have shown an insignificant upward movement over time. In the last 10 years the price/carton has increased $.0035 per week. Early-midseason orange price variability, 17% in October and 13% in January, is less than grapefruit. In addition, the last six years show October variations decreasing to 13% and January to 6%.

The inverse price/supply relationship holds for October (92 cars/week) but not for January (126 cars/week). While the highest volume is moved in December (311 cars/week), the weekly price index for the first two weeks of December is higher than the annual average (Table 2).

This distortion of the inverse relationship is caused by the heavy pre-Christmas promotional fruit sales. Shipments in December are as much as ⅔ destined for this market. Because promotional sales are not part of the regular retail marketing channel, they are not influenced by the normal supply and demand factors. Promotional sales are made on a firm price for delivery at a specific date.

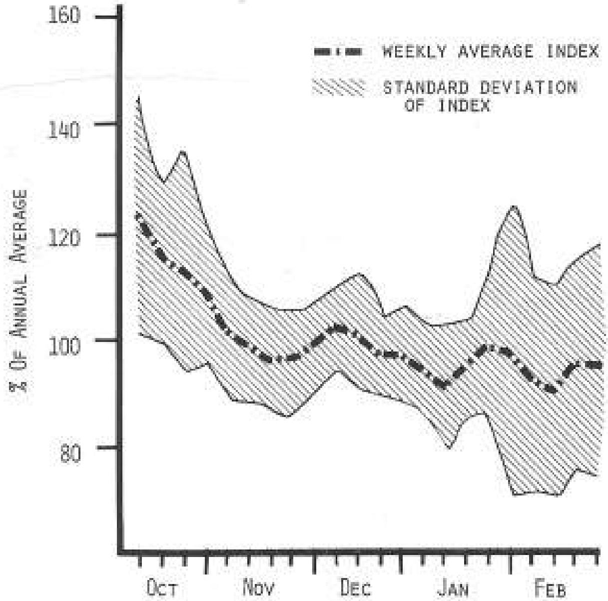

Fig. 4. Index of seasonal fob price variations: early-midseason oranges combination and no. 2 grades.

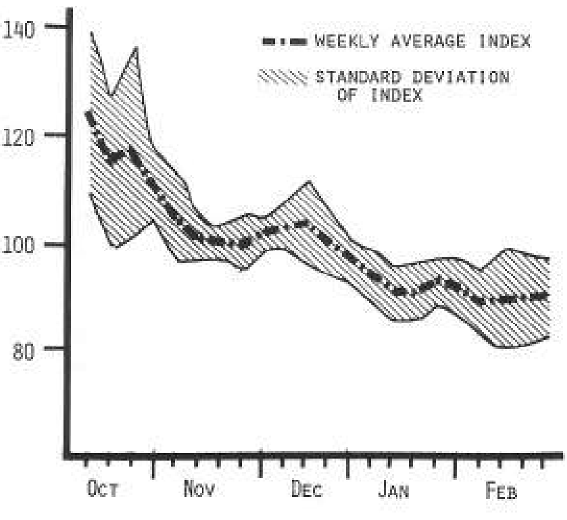

Fig. 5. Index of seasonal fob price variations: early-midseason oranges combination grade.

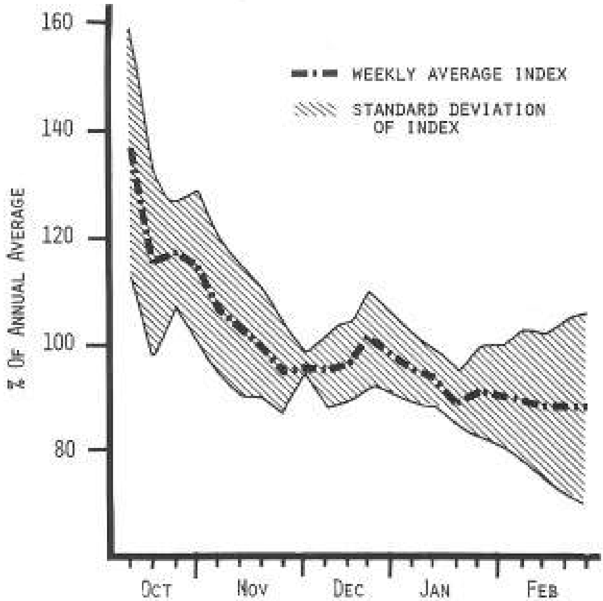

Fig. 6. Index of seasonal fob price variations: early-midseason oranges no. 2 grade.

Table 2. Average weekly early-midseason orange shipments by months by grades.

Month	Cars			Percent	
	Combination and no. 1	No. 2	Total	Combination and no. 1	No. 2
Oct.	62	30	92	67	33
Nov.	110	54	164	67	33
Dec.	214	97	311	69	31
Jan.	80	46	126	63	37
Feb.	59	33	92	64	36

The pre-Christmas sales particularly affect combination grade price but not no. 2 grade (Figs. 5, 6). The combination grade price index is 3 to 5% above the no. 2 price index during this last November-early December period. After December the normal price slump begins and January shipments probably reflect the normal supply and demand pattern.

While the price variability of early-midseason oranges is less than grapefruit, the no. 2 grade appears to influence the weighted FOB variability more than the combination grade. For example, in October no. 2 average weekly variability is 16% and combination grade 13%, as compared with a 17% variability in the weighted index. No. 2 variability falls to 7% in December and increases to 15% in February. Since the combination grade average weekly variability only rises from 5% in December to 8% in February, the weighted index appears to be responding more to no. 2 grade variability changes than to the combination grade.

The no. 2 variability is attributable to the promotional markets early in the season. However, late season variability primarily results from shippers experiencing a price squeeze/quality loss similar to that for grapefruit. The rapid decline in early-midseason orange quality plus the pressure to meet growers' pricing date requirements increases the volume of no. 2's available. Better quality fruit is moved into fresh channels and no. 2's are moved as best they can.

While about 66% of the early-midseason orange crop is harvested before January, this amount to 73% of the total fresh early-midseason orange shipment. Prior to January, processing accounts for 41% of the crop harvested, or for every one car shiipped fresh, .84 cars are processed.

Between January and the end of February 26% of the fruit harvest goes fresh. Of this, 37% are no. 2's in January and 36% in February. In this period 62% of the available crop is processed. In the last four years, processing has consumed 75% of the remaining crop, or for every one car shipped fresh, 1.9 cars are processed.

Seasonal Valencia orange prices — Valencia orange shipments amounted to 15% of all citrus harvested in Texas' 1976-77 season. Of the 4,480 cars produced, 2,182 went domestic, 153 to export, and 1,951 to processing through May. This is 26.5% of the total U.S. fresh Valencia movement from January through May. Florida's share of the market was 29.2% and Arizona-California 44.3%.

Valencia orange prices are highest in January and lowest in May (Fig. 7). In the month of March some prices strength is regained. There is a difference of 20% between January and May, 16% between March and May. Valencia prices are not influenced by the Christmas season since they are not harvested until January-February.

The variability associated with Valencia FOB prices is lower than either grapefruit or early midseason oranges. The variability, 15% in January, 6% in March and 17% in May, is also declining like all citrus varieties in Texas. In the last six years variability has fallen 6% in January, 2% in March and 6% in May. The trend is weekly Valencia prices increased from $.0028/carton/week over the last 10 years to $.0059/carton/week over the last 6 years.

Weekly average shipments of Valencias were 38 cars in January, 125 cars in March, and 41 cars in May (Table 3). The inverse price/supply relationship does not completely hold because heavy March shipments, which should mean low prices, instead are associated with a slight strengthening of prices.

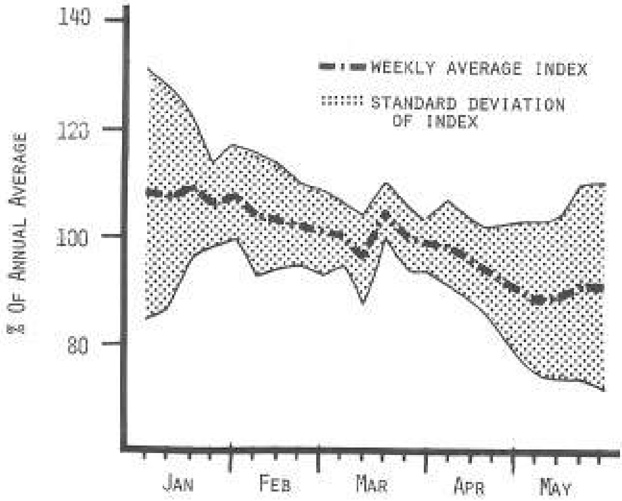

Fig. 7. Index of seasonal fob price variations: Valencia orange combination and no. 2 grades.

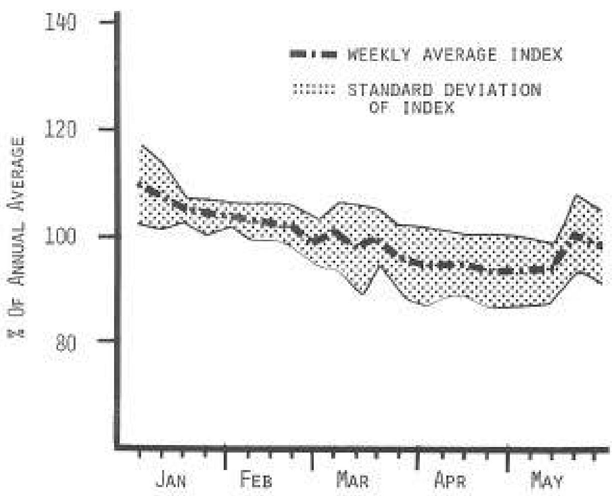

Fig. 8. Index of seasonal fob price variations: Valencia orange combinations grade.

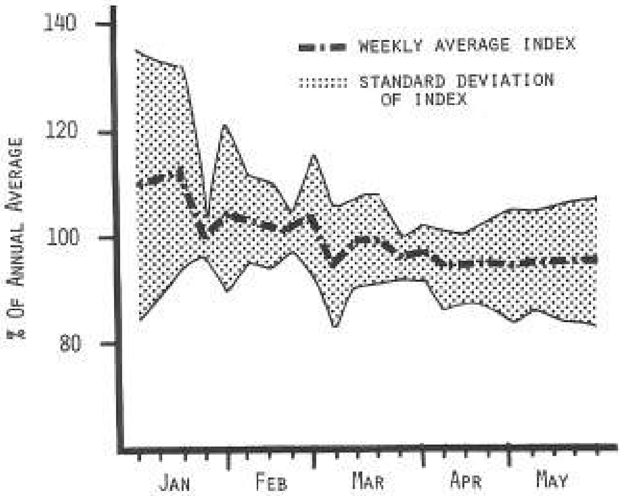

Fig. 9. Index of seasonal fob price variations: Valencia orange no. 2 grade.

Table 3: Average weekly Valencia orange shipments by months by grades.

Month	Cars: Combination and no. 1	Cars: No. 2	Cars: Total	Percent: Combination and no. 1	Percent: No. 2
Jan.	23	15	38	61	39
Feb.	56	40	96	58	42
Mar.	80	45	125	64	36
Apr.	49	30	79	62	38
May	27	14	41	66	34

Indices for the combination and no. 2 grade Valencias have a variation pattern similar to the early-midseason varieties (Figs. 8, 9). The no. 2 grade has an average weekly variation of 15% in January, 7% in March, and 11% in May. The average weekly variation for the combination grade is 4% in January, 6% in March, and 6% in May. Also, the variation of the weighted FOB index appears to be influenced more by the no. 2 than the combination grade.

The level and variability of the weighted FOB price index before March is directly influenced by the price and shipments of the remaining early-midseason orange crop. After March virtually all Texas shipments are Valencia oranges, which then determine their own price level.

Between December and February about 15% of the total Valencia crop is harvested. Valencia shipments average 38 cars/week in January and 96 cars in

February, as compared with early-midseason average weekly shipments of 126 cars in January and 92 cars in February. During this time, 1.9 cars of Valencia and early-midseason oranges are processed for every on car shipped fresh. After February virtually all early-midseason oranges are processed, while Valencia processing declines to 1.37 cars for each car shipped fresh. Fresh shipment variation after March is attributable to a declining shipper profit margin, quality deterioration, and the closing of independent juice plants.

CONCLUSIONS

Recurring seasonal factors influence weekly Texas citrus prices to create systematic patterns. Marketing strategy development should examine both these patterns and the special demand and supply forces, such as the grapefruit fad and the freeze in Florida, which affect each specific harvesting season.

The overall level of Texas citrus is only slightly increasing. Prices have trended upward less than $.004/carton/week over the last 10 years with most of this increase occuring in the last six years.

Variability of citrus prices has diminished since the 1962 freeze. Although supplies of all Texas citrus have increased there is still sufficient price variation to provide price uncertainty. The Texas citrus industry needs to improve its marketing ability to account for this continued price uncertainty.

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Citrus Costs and Returns In Texas 1975-76

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ABSTRACT

Cost and returns data from 135 growers are summarized and compared by variety and orchard size. Estimates of machinery ownership costs are compared to custom hired rates. Four budgets show costs and returns for grapefruit and orange orchards under owner or custom hired care. Gross returns ranged from $628 to $939/acre for grapefruit orchards, $386 to $516/acre for early mid-season oranges, and $325 to $488/acre for Valencia oranges. Insect and melanose control account for 18-23% of the total annual operating expense, fertilizer 7-11%, weed control 4-9%, water 7-8%, labor 16-18%, material application 21-35%, interest on operating capital 5-8%, and tree replacement 4-6%.

This study provides an understanding of Texas citrus growers' costs and returns. Through the cooperation of Texas Citrus Mutual and interested growers surveys were conducted during the summer of 1976. Data from the survey is presented by averages and ranges. It is not suggested that this is statistically significant data for all orchards in the area.

The report provides data for comparisons by varieties and acreage classes. Costs of production are delineated and machinery costs are estimated so that new citrus investors can obtain the basic information required in making a buying decision. In addition, answers to many other costs and return questions are presented.

GENERAL INFORMATION

The survey included 135 citrus growers who sold their fruit through cooperatives or local independent shippers. Names and orchard locations were obtained from Texas Citrus Mutual. Orchards were selected from a stratified random sample to insure balanced geographic and acreage size representation. The survey included 7,726 acres of citrus delineated as follows: east of Mercedes, the lower Valley; Mercedes to Alamo, mid Valley; and west of Alamo, the upper Valley (Table 1). Acreage classes and the average size of an orchard are shown in Table 2.

Citrus owners surveyed generally grow more than one variety either within one orchard or as solid planted orchards in different locations. In the 11-25 acre class the average Ruby Red grapefruit orchard was 12.2 acres (Table 3). The average Star Ruby grapefruit orchard was 4.6 acres. Oranges in the 11-25 acreage category averaged 7 acres for early mid-season varieties or 7.2 acres of Valencias.

Table 1. Location and variety class of survey orchards.

Variety	Lower Valley	Mid Valley	Upper Valley
		(acres)	
Ruby Red	758	823	2820
Star Ruby	21	-0-	126
Early mid-season oranges	9	360	1260
Valencia oranges	7	414	1128
TOTAL ACRES	795	1597	5334
Percent of Total	10.3	20.7	69.0

Table 2. Orchard size classes.

Acreage class	Orchards surveyed	Total acres in class	Average acreage per class
≤ 10	44	300	6.8
11-25	39	713	18.3
26-50	24	895	37.3
51-75	11	656	59.6
76-100	8	628	78.5
> 100	9	4,334	481.6

Table 3. Varietal breakdown by orchard size class.

Acreage class	Ruby Red	Star Ruby	Early mid-season oranges	Valencia oranges
≤ 10	5.4	2.5	5.8	4.4
11-25	12.2	4.6	7.0	7.2
26-50	26.4	-0-	20.0	20.3
51-75	33.4	20.7	18.8	26.6
76-100	55.3	-0-	24.1	25.9
> 100	302.6	44.0	126.5	142.4

Younger orchards have more than 100 trees per acre. Older plantings tend to be the larger holdings with smaller tree populations (Table 4). The trend is toward more trees per acre, as is evidenced by the Star Ruby plantings which were first planted in 1972.

Table 4. Number of trees per acre by variety and acreage class.

Acreage class	Ruby Red	Star Ruby	Early mid-season oranges	Valencia oranges
≤ 10	103	116	103	108
11-25	117	120	111	113
26-50	100	140	101	97
51-75	111	114	101	104
76-100	85	-	109	85
> 100	105	116	100	104
Overall average	104	121	104	102

Yields are related to tree age. In the Valley, where freeze damage is probably the greatest production response variable, yields of older orchards are more likely to reflect damage from one or more freezes (Table 5). Average Valencia yields appear to peak between 5-10 years of age and maintain this plateau irrespective of freeze damage. Grapefruit trees improve production generally through the 20th year, then begin a slow decline. Oranges apparently have a few years of greater longevity.

Table 5. Tons per acre by variety and age of orchard.

Orchard age	Ruby Red			Early mid-season oranges			Valencia oranges		
(years)	Low	Mean	High	Low	Mean	High	Low	Mean	High
5-10	9.9	14.1	18.3	7.9	11.7	15.6	8.5	10.8	13.1
11-15	11.2	16.1	21.0	8.7	13.1	17.5	7.4	10.6	13.9
16-20	12.2	15.9	19.5	7.7	11.0	14.2	7.1	10.6	14.1
21-25	8.8	13.7	18.5	7.8	11.7	15.5	5.4	10.4	15.3
> 25	7.2	12.6	18.0	5.7	9.0	12.3	7.4	11.7	15.9

The 26-50 acre class indicates the relationship between yield and size of orchard (Table 6). Larger orchards with older trees (Table 7) and smaller tree populations (Table 4) have lower yields per acre. Orchards smaller than 26-50 acres also tend to have lower yields, possibly because they have a greater ownership turnover and hence less intensive management.

Table 6. Tons per acre by variety and acreage class.

Acreage class	Ruby Red			Early mid-season oranges			Valencia oranges		
	Low	Mean	High	Low	Mean	High	Low	Mean	High
≤10	11.7	15.5	19.3	7.8	11.5	15.3	8.0	11.8	15.6
11-25	10.1	14.7	19.3	7.7	11.3	14.9	5.6	10.2	14.7
26-50	10.9	16.6	22.3	7.8	12.7	17.6	7.7	11.5	15.2
51-75	6.2	12.9	19.6	8.3	10.2	12.1	7.5	11.2	14.9
76-100	10.2	13.9	17.5	9.3	10.4	11.6	6.8	10.2	13.6
> 100	8.7	12.5	16.3	6.4	9.7	13.0	6.7	9.7	13.5

Table 7. Orchard age by variety and acreage class.

Acreage class	Ruby Red			Early mid-season oranges			Valencia oranges		
	Low	Mean	High	Low	Mean	High	Low	Mean	High
≤ 10	7.4	14.1	20.7	12.3	18.8	25.3	12.8	18.4	24.0
11-25	7.5	13.6	19.8	9.1	15.8	22.6	9.6	13.6	17.6
26-50	9.6	16.5	23.4	9.8	15.9	22.0	11.6	17.8	23.9
51-75	10.3	18.3	26.3	11.3	18.8	26.2	15.0	19.5	24.0
76-100	12.3	18.4	24.5	14.8	18.8	22.8	16.0	18.0	20.0
> 100	13.6	19.4	25.3	15.8	21.1	26.5	15.2	21.5	27.8

CITRUS RETURNS

Independent growers indicated a range for Ruby Red grapefruit of $30 to $87.50/ton on a clean-the-tree basis with the average at $48.90. Ring picking for Ruby Red grapefruit ranged from $45 to $85 with an average of $61.58. Prices on a clean-the-tree basis for all oranges ranged from $30 to $55/ton with a $36.80 average. As acreage increased the price received for grapefruit increased (Table 8). This also occurs in both the grapefruit and orange components of mixed orchards (Table 9). Data are insufficient to confirm this with growers who own only oranges (Table 10).

From tables 8, 9 and 10 an estimate of gross income per acre can be determined by acreage class and variety (Table 11). The 26-50 acre and 51-75 acre classes are the better gross income producing orchards. Income of the larger acreage classes is reduced due to lower yields, smaller tree populations and older trees.

Orchards of less than 25 acres have a higher percentage of mixed variety plantings. If oranges and grapefruit are interset, i.e., interplanted in the same row, picking costs are increased. Picking crews must cover the same distance down the tree row in order to pick every other tree. An interset grapefruit-orange orchard reduces labor productivity, necessitating higher picking cost/ton to the shipper and lower prices to the grower.

Table 8. Grapefruit yields and prices received by cooperative and independent growers by acreage class.

Acreage class	Cooperative Growers		Independent Growers		
	Number	Tons/ acre	Number	Clean tree price	Tons/ acre
≤ 10	3	19.9	16	$49.56	16.9
11-25	3	15.9	9	51.11	16.4
26-50	4	11.2	2	52.50	15.0
51-75	2	8.8	[1]	-	-
76-100	2	13.0	[1]	-	-
> 100	[1]		[1]	-	-

[1] Suppressed.

Small orchards do not provide as wide a range nor as large a volume of fruit sizes. Crews in large acreage can continually pick a steady supply of a given size for most of the season. Small orchards, on the other hand, may provide two or three days picking on a given ring size and then require several months before another profitable harvest.

Small orchards are typically sideline businesses and not primary income producing enterprises. Owners view their investment more as tax shelters and capital gains income. This approach leads to poor management, cuts in production expenditures and declining quality of fruit offered for sale.

COSTS OF GROWING CITRUS

Insecticide material. Insecticide material, the most expensive operating input, varies from 20 to 30% of the total annual operating costs. For a grapefruit orchard of 26-50 acres the average annual insecticide expense was $60.99/acre (Table 12). By application date these expenses were: post bloom $16.62, early summer $18.75, late summer $18.79, and fall $19.90. Not all growers use or require four sprays each year. A weighted costs per application was developed to compare spray material costs by variety and acreages. This was the sum of the total material costs for all orchards of a given acreage class divided by the total number of applications. The weighted spray cost/acre/application was $18.29 for a 26-50 acre grapefruit orchard. A 26-50 acre orange orchard's weighted spray costs was $19.52/acre (Table 13). A comparable sized mixed orchard's weighted spray costs was $20.27/acre (Table 14).

Table 9. Mixed orchard yields and prices received by cooperative and independent growers by acreage class.

Acreage class	Cooperative growers				Independent Growers					
		Tons/acre[1]				Clean tree price		Tons/acre		
	Number	Gpft	EMO	VO	Number	Gpft	Oranges	Gpft	EMO	VO
≤ 10	3	14.2	12.0	-	13	$45.19	$38.84	13.9	11.5	11.8
11-25	7	12.4	11.6	11.1	14	48.25	39.71	14.7	11.3	10.3
26-50	5	17.9	14.3	13.0	7	49.94	38.82	18.8	13.3	12.3
51-75	2	5.7	9.4	-	6	53.00	46.00	16.2	11.0	10.6
76-100	4	14.5	10.6	9.5	-[2]	-	-	-	-	-
> 100	6	12.5	10.3	10.9	2	56.25	40.62	11.5	9.5	8.0

1 Gpft, EMO and VO stand for grapefruit, early mid-season oranges, and Valencia oranges, respectively.

2 Suppressed.

Table 10. Orange yields and prices received by cooperative and independent growers by acreage class.

Acreage Class	Cooperative growers			Independent growers			
	No./ class	Tons/ acre		No./ class	Clean tree price	Tons/ acre	
		EMO	VO		All oranges	EMO	VO
≤ 10	4	10.1	10.3	5	$36.80	13.1	12.5
11-25	4	9.1	-	-	-	-	-
26-50	5	9.7	-	-	-	-	-

Table 11. Estimated gross income per acre for surveyed growers.

Acreage class	Grapefruit[1]	Early mid-season oranges [2]	Valencia oranges[2]
≤ 10	$628	$447	$459
11-25	709	448	409
26-50	939	516	477
51-75	859	506	488
76-100[3]	-	-	-
> 100	647	386	325

1 Developed using clean-the-tree prices and average tons produced/acre from (Table 9).

2 Income differences between orange categories are due only to differences in yield/acre.

3 Suppressed.

Table 12. Cost of insecticides per acre for grapefruit orchards.

Acreage class	Total cost			Average Cost				Weighted/ spray average
	Low	Mean	High	Post bloom	Early summer	Late summer	Fall	
≤ 10	$53.68	77.63	101.58	$25.77	$24.27	$27.18	$24.17	$22.31
11-25	41.19	71.47	101.75	19.62	22.71	17.59	23.51	21.09
26-50	44.37	60.99	81.71	16.62	18.75	18.79	19.90	18.29
51-75	54.56	55.94	57.32	22.38	21.88	16.04	13.14	18.64
76-100	35.38	50.50	65.62	11.09	20.03	28.98	14.58	16.83
> 100[1]	-	-	-	-	-	-	-	-

1 Suppressed.

Table 13. Cost of insecticides per acre for orange orchards.

Acreage class	Total cost			Average cost				Weighted/ spray average
	Low	Mean	High	Post bloom	Early summer	Late summer	Fall	
≤ 10	$29.75	49.59	$69.43	$23.11	$22.95	$20.05	$23.29	$22.31
11-25	63.39	77.34	91.29	11.28	21.70	18.37	23.96	20.61
26-50	28.79	62.55	96.31	16.12	19.85	24.93	17.76	19.52

Table 14. Cost of insecticides per acre for mixed orchards.

Acreage class	Total cost			Average cost				Weighted/ spray average
	Low	Mean	High	Post bloom	Early summer	Late summer	Fall	
≤ 10	$57.67	$81.82	$105.97	$23.97	$27.21	$26.04	$24.84	$25.36
11-25	52.17	70.26	88.35	21.23	21.50	21.44	19.51	20.95
26-50	44.29	68.93	93.57	18.99	21.03	20.38	21.09	20.27
51-75	49.36	73.95	98.54	25.06	25.25	25.29	19.05	24.64
76-100	46.32	73.39	100.46	25.85	23.09	22.92	26.82	24.46
>100	45.32	68.58	91.84	18.95	19.28	20.38	21.88	20.00

Herbicide material. Weed control in Valley orchards is accomplished with chemicals, mechanical cultivation, or a combination of the two. The percent of orchards surveyed using a particular method of weed control is given (Table 15). About 44% of the orchards surveyed had received some chemical application of weed control. Acreage size has little to do with the method employed.

Weed control represents 10-15% of annual expenses; the average was $29.68/acre for grapefruit, $15.47 for oranges, and $33.56 for mixed orchards (Table 16). The survey suggested that as orchard acreage increases so does herbicide cost/acre. Larger growers who used chemical weed control believed that routine use of herbicide was more labor efficient.

Fertilizer. Fertilizer accounts for about 10% of annual expenses. The grapefruit grower can expect to spend $30 to $37, orange grower $21-$37, and mixed variety grower $26-$40/acre/year. The amount of fertilizer used was quite variable (Table 17). Only two growers surveyed said they did not regularly fertilize.

Irrigation practices. Irrigation methods and costs were similar for all varieties and acreage classes. Surface-flood irrigation was used in 98% of citrus orchards; the remaining 2% were drip irrigated. Differences in irrigation practices are largely due to topography, delivery of water and labor requirements.

Table 15. Weed control methods.

Acreage class	Grapefruit			Oranges			Mixed		
	Chemical	Cult.	Both	Chemical	Cult.	Both	Chemical	Cult.	Both
					(%)				
≤ 10	35	60	5	44	56	-	64	23	13
11-25	58	42	-	-	100	-	42	42	16
26-50	28	57	8	-	100	-	55	45	-
51-75	50	50	-	-	-	-	57	43	-
76-100	33	67	-	-	-	-	40	40	21
> 100[1]		-	-	-	-	-	37	26	37

[1] Suppressed

Table 16. Cost of herbicides per acre by variety and acreage class.

Acreage class	Grapefruit			Oranges			Mixed orchards		
	Low	Mean	High	Low	Mean	High	Low	Mean	High
≤10	$14.30	$24.57	$34.84	$7.23	$15.47	$23.71	$14.40	$32.64	$50.88
11-25	20.00	28.87	37.74	-	-	-	22.23	34.04	45.85
26-50	17.03	32.04	47.05	-	-	-	21.06	34.81	48.56
51-75	25.50	30.06	34.62	-	-	-	27.01	34.63	42.25
76-100[1]	-		-	-	-	-	9.90	36.67	63.44
>100[1]	-	-	-	-	-	-	24.84	39.67	54.50
Overall average		$29.68			$15.47			$35.56	

[1] Suppressed.

Table 17. Fertilizer costs per acre by variety and acreage class.

Acreage class	Grapefruit			Oranges			Mixed		
	Low	Mean	High	Low	Mean	High	Low	Mean	High
≤ 10	$19.90	$29.60	$39.30	$ 2.00	$21.43	$40.15	$ 7.92	$26.13	$44.34
11-25	17.85	30.82	43.79	29.14	37.48	45.82	16.89	35.69	54.49
26-50	28.66	37.32	45.98	8.42	25.66	42.90	19.61	36.21	52.81
51-75[1]	-	-	-	-	-	-	23.29	33.93	44.57
76-100	14.82	27.38	39.94	-	-	-	31.49	37.25	43.01
>100[1]	-	-	-	-	-	-	25.81	40.19	54.57

[1] Suppressed.

Larger acreages were irrigated fewer times and with less water each year but required slightly more labor (Table 18). These holdings generally include more unlevel, difficult to water orchards.

The amount of water available, which can be quite variable, will often compound the topography and labor problems. Competing noncitrus crops peak season water requirements also tend to lessen the volume of water delivered.

Table 18. Annual irrigation costs/acre for all citrus.

Acreage Class	Number of irrigations	Water charge/ irrigation	District assessment/ acre	Acre inches applied/ irrigation	Hours/ irrigation
≤ 10	3.8	$5.41	$7.88	6.9	$.7
11-25	3.8	4.76	9.07	6.9	1.2
26-50	3.9	5.18	7.58	6.6	1.8
51-75	3.7	6.96	8.57	7.4	1.9
76-100	3.4	4.26	6.61	6.4	1.8
> 100	3.2	5.62	8.77	5.4	1.8
Overall average	3.6	$5.37	$8.08	6.6	1.7

Cultural practices. Cultural practices are classified by weed control methods and orchard care. Weed control is accomplished by clean cultivation or chemical means. Orchard care is provided either by custom hiring all equipment and labor (custom care) or by owner supplied equipment and labor (owner care).

Owner care under chemical weed control requires a tractor, herbicide sprayer, insecticide sprayer, disc, and border machine. Clean cultivation eliminates the herbicide sprayer but adds the tree hoe. The survey's equipment cost for the chemical weed control system was $11,850; for the clean cultivation system $8,050 (Table 19).

The level of materials used in the orchard is reflected in the accompanying budgets. Since practices in mixed orchards were similar to grapefruit orchards they are grouped together. Mixed orchard owners can use cost estimates developed for grapefruit.

Machinery expenses by variety, acreage size, and type of weed control were developed from survey data (Tables 20, 21, 22, 23). These estimates of machinery ownership costs, i. e., depreciation, taxes, insurance, repair and maintenance, interest and principal payments should be qualified. For example, an insecticide sprayer can cover 1.8 acres/hr, but this is only field time or actual spraying time and does not include refilling and movement to the orchard. The time estimates for the insecticide and herbicide sprayers should be adjusted upward to indicate total time required. This could be as much as 50% depending upon distance to the orchard and to an acceptable water source.

In addition, the grower should consider the orchard's soil type. Since machinery's greatest useage typically falls during the heaviest rainfall periods, its capabilities can be overstated unless soil type is considered. Generally, the field time requirements can be increased by 1/3 for sandy loam soils to 1/2 for sandy clay loam soils to reflect the delay and difficulties encountered by rainfall and wet soils.

Custom care application charges/acre were about equal for all varieties and acreage classes (Table 24). Differences in cost occurs with the type of weed control employed. Total application costs/acre indicate that clean cultivation was more expensive than chemical weed control. The increase cost was due to the number of times the disc, tree hoe, and border machine were used/acre. Adding the cost of the herbicide material to the chemical weed control system would make the difference between the two systems negligible.

A comparsion of cultural programs is provided in Table 25. The orchard owner who chooses to hire custom care is better off using a chemical weed control program. This holds for both grapefruit and oranges in all acreage categories.

Clean cultivation is less expensive than chemical weed control under a owner operated system. A primary reason for using herbicides is the residual effect which reduces the need for constant weed control. Time is made available for other critical orchard operations which compete for labor. The Valley's highest rainfall period typically occurs when growers must perform most of their cultural practices. Chemical weed control reduces the labor-machinery requirement needed to properly manage the orchard.

Table 19. Machinery complement

Equipment item	Average list price	Equipment size	Current age (years)	Expected life (years)	Acres/ hr in field
1) Tractor	$5,500	46 hp	7.0	12	-
2) Herbicide sprayer	4,300	185 gal	4.6	10	2.2
3) Insecticide sprayer	4,000	406 gal	11.4	10	1.8
4) Border machine	850	7.4 ft	7.2	10	2.2
5) Tree hoe	500		6.5	10	3.3
6) Disc	800	8 ft	9.7	10	2.2

Table 20. Estimated machinery costs for grapefruit under chemical weed control by acreage class.

Item	≤ 10	11-25	26-50	51-75	76-100	>100
			($/acre)			
Machinery ownership costs	$143.78	$ 52.03	$ 29.09	$ 17.62	13.80	$10.74
Principal and interest	148.63	49.54	24.77	12.38	8.26	4.95
Herbicide material	24.57	28.87	32.04	30.06	36.67	39.67
Total cultural system cost	$316.98	$130.44	$ 85.90	$ 60.06	$58.72	$55.36
Insecticide sprayer ownership costs	136.77	54.12	33.46	23.12	19.68	16.93
Insecticide sprayer principal and interest costs	253.07	84.35	42.17	31.08	14.05	8.43
Total insecticide sprayer cost	$389.84	$138.47	$ 75.63	$ 54.20	$33.73	$25.36
Overall total system cost	$706.82	$268.91	$161.53	$114.26	$92.45	$80.72

Table 21. Estimated machinery costs for grapefruit under clean cultivation by acreage class.

Item	≤ 10	11-25	26-50	51-75	76-100	>100
			($/acre)			
Machinery ownership costs	$121.84	$ 56.97	$ 40.78	$ 32.66	$29.97	$27.81
Principal and interest	215.05	71.68	35.84	17.92	11.94	7.16
Herbicide material	-	-	-	-	-	-
Total cultural system cost	$336.87	$128.65	$ 76.62	$ 50.58	$41.91	$34.97
Insecticide sprayer ownership costs	121.43	44.80	28.79	20.80	18.13	16.00
Insecticide sprayer principal and interest costs	87.84	29.27	14.63	7.31	4.87	2.92
Total insecticide sprayer cost	$209.26	$ 74.07	$ 43.42	$ 28.11	$23.00	$18.92
Overall total system cost	$546.13	$202.72	$120.04	$ 78.69	$64.91	$53.89

Table 22. Estimated machinery costs for oranges under chemical weed control by acreage class.

Item	≤ 10	11-25	26-50	51-75	76-100	>100
			($/acre)			
Machinery ownership costs	$143.17	$ 51.42	$ 28.48	$ 17.01	$13.19	$10.13
Principal and interest	148.63	49.54	24.77	12.38	8.25	4.95
Herbicide material	15.47	15.47	15.47	15.47	15.47	15.47
Total cultural system cost	$307.27	$116.43	$ 68.72	$ 44.86	$36.91	$30.55
Insecticide sprayer ownership costs	133.61	50.96	30.30	19.96	16.52	13.77
Insecticide sprayer principal and interest costs	253.07	84.35	42.17	31.08	14.05	8.43
Total insecticide sprayer cost	$386.68	$135.31	$ 72.47	$ 51.04	$30.57	$22.20
Overall total system cost	$693.95	$251.74	$141.19	$ 95.90	$67.48	$52.75

Table 23. Estimated machinery costs for oranges under clean cultivation by acreage class.

Item	≤ 10	11-25	26-50	51-75	76-100	> 100
			($/acre)			
Machinery ownership costs	$115.80	$ 50.93	$ 34.74	$ 26.62	$23.93	$21.77
Principal and interest	215.05	71.68	35.84	17.92	11.94	7.16
Herbicide material	-	-	-	-	-	-
Total cultural system cost	$330.95	$122.61	$ 70.58	$ 44.54	$35.87	$28.93
Insecticide sprayer ownership costs	118.24	41.63	25.62	17.63	14.96	12.83
Insecticide sprayer principal and interest costs	87.84	29.27	14.63	7.31	4.87	2.92
Total insecticide sprayer cost	$206.08	$ 70.90	$ 40.25	$ 24.94	$19.83	$15.75
Overall total system cost	$536.93	$193.51	$110.83	$ 69.48	$55.70	$44.68

Table 24. Number of applications and costs per acre for custom hired operations for grapefruit and oranges.

	Grapefruit				Oranges			
	Chemical weed control		Clean cultivation		Chemical weed control		Clean cultivation	
	Applications/ acre	Cost/ acre	Applications/ acre	Cost/ acre	Applications/ acre	Cost/ acre	Applications/ acre	Cost/ acre
Insecticide Application	4.00	$49.28	4.0	$ 49.28	3.0	$36.96	3.0	$36.96
Herbicide Application	2.25	15.32	-	-	2.0	13.62	-	-
Discing	.33	1.43	7.0	30.45	.33	1.43	5.0	21.75
Tree Hoe	-	-	2.0	8.70	-	-	2.0	8.70
Border making	.33	1.43	4.0	17.40	.33	1.43	3.0	13.05
Total cost/ acre		$67.46		$105.83		$53.44		$80.46

Table 25. Comparison of custom hired and owner care costs for grapefruit and oranges.

Acreage class	Grapefruit				Oranges			
	Custom hired		Owner care		Custom hired		Owner care	
	Chemical weed control	Clean cultivation	Chemical weed control	Clean cultivation	Chemical weed control	Cleam cultivation	Chemical weed control	Clean cultivation
				(Costs/acre)				
≤ 10	$ 92.04[1]	$105.83	$706.82	$546.13	$68.91	$80.46	$693.95	$536.93
11-25	96.34	105.83	268.91	202.72	68.91	80.46	251.74	193.51
26-50	99.51	105.83	161.53	120.04	68.91	80.46	141.19	110.83
51-75	97.53	105.83	114.26	78.69	68.91	80.46	95.90	69.48
76-100	104.14	105.83	92.45	64.91	68.91	80.46	67.48	55.70
> 100	107.14	105.83	80.72	53.89	68.91	80.46	52.75	44.68

1 Uses herbicide material costs developed in Table 18 in order to show the comparison between cultural systems.

ORCHARD BUDGETS

The final stage of the survey develops budgets to provide baseline cost and returns data for growers. The budgets which utilize information listed in the proceeding tables are developed for grapefruit and oranges by custom hired or owner care (Table 26, 27, 28, 29).

Table 26. Estimated costs and returns per acre for mature 26-50 acre grapefruit orchard; owner care, 1975/76 season.

	Unit	Price/ unit	Quantity/ acre	Value
1. Production	Tons	$ 52.50	15.0	$787.50
Advertising	$	.80	15.0	12.00
Total receipts				$775.50
2. Operating inputs (variable costs)				
Insecticide	Acre	60.99	1.0	$ 60.99
Melanose	Acre	13.05	1.0	13.05
Herbicide	Acre	32.04	1.0	32.04
Fertilizer	Acre	37.32	1.0	37.32
Tree replacement	Tree	3.50	5.0	17.50
Irrigation	Appl.	7.07	4.0	28.28
Total material costs				$189.18
3. Labor costs				
Irrigation (4/year)	Hr	2.50	8.0	$ 20.00
Machinery	Hr	2.50	3.5	8.75
Hand	Hr	2.50	15.00	37.50
Total labor costs				$ 66.25
4. Interest on operating capital	%	9.0	1.0	$ 22.99
5. Total operating costs				$278.42
6. Income above operating costs				$497.08
7. Machinery costs	Acre	120.74	1.0	$120.74
8. Fixed costs				
Taxes, bonds, flat rates	Acre	18.33	1.0	$ 18.33
Depreciation on trees	Acre	.083	1250.00	103.75
Interest on trees	Acre	.06	1250.00	75.00
Interest on land	Acre	.06	1000.00	60.00
9. Total fixed costs				$257.08
10. Total costs/acre				$656.24
11. Net return to risk and management				$119.26

Each budget is divided into areas of concern to management's decision-making process.

Production-Receipts: Tons produce/acre, prices received/ton, marketing charges for sale of fruit by grove care company and TexaSweet advertising assessment.

Table 27. Estimated costs and returns per acre for mature 26-50 acre orange orchard, owner care, 1975/76.

	Unit	Price/ unit	Quantity/ acre	Value
1. Production	Tons	$ 38.82	12.68	$492.24
Advertising	$	.89.0	12.68	10.15
Total receipts				$482.10
2. Operating inputs (variable costs)				
Insecticide	Acre	62.55	1.0	$ 62.55
Herbicide	Acre	15.47	1.0	15.47
Fertilizer	Acre	25.66	1.0	25.66
Tree replacement	Tree	3.50	5.0	17.50
Irrigation	Appl.	7.70	3.0	23.10
Total material costs				$144.28
3. Labor costs				
Irrigation	Hr	2.50	5.7	$ 14.25
Machinery	Hr	2.50	2.9	7.25
Hand	Hr	2.50	15.0	37.50
Total labor costs				$ 59.00
4. Interest on operating capital	%	9.0	1.0	$ 18.30
5. Total operating costs				$221.58
6. Income above operating costs				$260.52
7. Machinery costs	Acre	118.47	1.0	$118.47
8. Fixed costs				
Taxes, bonds, flat rates	Acre	18.33	1.0	$ 18.33
Depreciation on trees	Acre	.083	1000.00	83.00
Interest on trees	Acre	.06	1000.00	60.00
Interest on land	Acre	.06	1000.00	60.00
9. Total fixed costs				$221.33
10. Total costs/acre				$561.38
11. Net return to risk and management				(-$ 79.28)

Operating Inputs: Annual operating expenses used in the production of the crop. Includes materials and grove application costs and rates/acre.

Labor Costs: Labor uses and costs.

Interest on Operating Capital: Interest cost of borrowed money for annual expenditures or opportunity cost of owners money.

Total Operating Costs: Total annual operating expenditures/acre.

Income Above Operating Costs: Gross receipts less marketing, advertising, operating, labor costs and interest on operating capital.

Machinery Costs (Care by Owner): Depreciation, insurance, taxes, repair and maintenance, and principal and interest costs.

Fixed Costs: Costs associated with ownership of the land and trees. Not affected by the level of production nor amount of annual operating inputs.

Total Costs Per Acre: Sum of total operating and fixed costs.

Net Return to Risk and Management: The residual amount of money left to the owner's risk assumption and managerial abilities.

Table 28. Estimated costs and returns per acre for mature 26-50 acre grapefruit orchard, under custom hired care, 1975/76 season.

	Unit	Price/ unit	Quantity/ acre	Value
1. Production	Tons	$ 52.50	15.0	$787.50
Marketing cost	%	5.0	1.0	39.37
Advertising	$	.80	15.0	12.00
Total receipts				736.13
2. Operating inputs (variable costs)				
Material costs				
Insecticide	Acre	60.99	1.0	$ 60.99
Melanose	Acre	13.05	1.0	13.05
Herbicide	Acre	32.04	1.0	32.04
Fertilizer	Acre	37.32	1.0	37.32
Tree Replacement	Tree	3.50	5.0	17.50
Irrigation	Appl.	7.07	4.0	28.28
Total material costs				$189.18
Application costs				
Insecticide	Appl.	12.32	4.0	$ 49.28
Herbicide	Appl.	6.80	2.25	15.30
Fertilizer	Appl.	3.50	1.0	3.50
Borders (1/3/year)	Appl.	4.35	.33	1.43
Discing (1/3/year)	Appl.	4.35	.33	1.43
Total application costs				$ 70.94
Labor costs				
Irrigation (4/year)	Hr	2.50	8.0	$ 20.00
Hand	Hr	2.50	15.0	37.50
Total labor costs				$ 57.50
3. Interest on operating capital	%	9.0	1.0	$ 28.56
4. Total Operating Costs				$346.18
5. Income above operating costs				$389.95
6. Fixed costs				
Taxes, bonds, flat rates	Acre	18.33	1.0	$ 18.33
Depreciation on trees	Acre	.083	1250.00	103.75
Interest on trees	Acre	.06	1250.00	75.00
Interest on land	Acre	.06	1000.00	60.00
7. Total fixed costs				$257.08
8. Total costs/acre				$603.26
9. Net return to risk and management				$132.87

Table 29. Estimated costs and returns per acre for mature 26-50 acre orange orchard, under custom hired care, 1975-76 season.

	Unit	Price/ unit	Quantity/ acre	Value
1. Production	Tons	$ 38.82	12.68	$492.24
Marketing cost	%	5.0	1.0	24.61
Advertising	$	.80	12.68	10.14
Total receipts				$457.49
2. Operating inputs (variable costs)				
Material costs				
Insecticide	Acre	62.55	1.0	$ 62.55
Herbicide	Acre	15.47	1.0	15.47
Fertilizer	Acre	25.66	1.0	25.66
Tree replacement	Tree	3.50	5.0	17.50
Irrigation	Appl.	7.70	3.0	23.10
Total material costs				$114.28
Application costs				
Insecticide	Appl.	12.32	3.0	$ 36.96
Herbicide	Appl.	6.80	2.0	13.60
Fertilizer	Appl.	3.50	1.0	3.50
Borders (1/3/year)	Appl.	4.35	.33	1.43
Discing (1/3/year)	Appl.	4.35	.33	1.43
Total application costs				$ 56.92
Labor costs				
Irrigation (3/year)	Hr	2.50	5.7	$ 14.25
Hand	Hr	2.50	15.0	37.50
Total labor costs				$ 51.75
3. Interest on operating capital	%	9.0	1.0	$ 22.77
4. Total operating costs				$275.72
5. Income above operating costs				$181.77
6. Fixed costs				
Taxes, bonds, flat rates	Acre	18.33	1.0	$ 18.33
Depreciation on trees	Acre	.083	1000.00	83.00
Interest on trees	Acre	.06	1000.00	60.00
Interest on land	Acre	.06	1000.00	60.00
7. Total fixed costs				$221.33
8. Total costs/acre				$497.05
9. Net return to risk and management				(-$ 39.56)

Comparison of Reflectance Measurements with Photographs for Early Freeze Detection on Leaves of Sour Orange Plants

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ABSTRACT

Laboratory reflectance was measured on leaves from frozen (freeze treatment) and nonfrozen sour orange (*Citrus aurantium* Linn.) plants. Frozen leaves had about 15 percentage points less near-infrared light (0.75 to 1.35 um) reflectance than nonfrozen leaves within 5 hr after the freeze treatment.

Infrared and conventional color photographs did not show any differences in leaf appearance between frozen and nonfrozen plants, until about 30 hr after the freeze treatment. Therefore, reflectance measurements may be better than infrared and conventional color photographs for detecting early freeze damage to sour orange plant leaves.

Mapping cold-night surface temperatures with a thermal scanner or radiation thermometer is a promising technique to predict freeze conditions (6, 7, 10). Photography is also useful for assessing freeze damage if leaf discoloration or leaf drop has occurred. However, the usefulness of reflectance measurements must be compared with that of photography to detect early freeze damage to citrus leaves.

We compared the leaf reflectances and photographs of frozen and nonfrozen sour orange plants to determine which method was most useful for detecting early freeze damage of leaves.

MATERIALS AND METHODS

One-year old sour orange seedlings were in pots grown in an unshaded greenhouse that was cooled with air circulated through moist pads. Temperatures ranged from 23.9 to 35 C (75 to 95 F) with a 70 to 95% humidity. Ten plants were left in the greenhouse (nonfrozen plant treatment), and 10 were moved to a freezing chamber (frozen plant treatment). The temperature regime was 4.4 C (40 F) for 1 hr after which it was decreased at a rate of 1.1 C/hr (2 F/hr), until it reached -7.8 C (18 F) at which it remained for 4 hr. Then the temperature was increased to 4.4 C (40 F) at a rate of 1.1 C/hr (2 F/hr). When the temperature reached 4.4 C (40 F), both frozen and nonfrozen plants were placed in a bioclimatic chamber whose temperature was 15.6 C (60 F) at 48 to 52% relative humidity with continuous lighting (about 1,200 ft-c at plant level). The plants were not watered while they were in the chambers.

Leaves from all plants were collected to measure reflectance and thickness measurements and to determine their chlorophyll and water content at 1 to 4, 6 to 9, 11 to 14, 24 to 27, and 48 to 51 hr after plants were placed in the bioclimatic chamber. Leaves were randomly selected from each plant within an 18-inch interval of stem length beginning about 10 inches below the plant's apex.

Nonfrozen and frozen plant leaves were photographed at a distance of 3.5 m (11.5 ft) with electronic flash at about 3-hr intervals from 9:00 AM to 11:00 PM on day 1, from 8:15 AM to 4:30 PM on day 2, and from 8:15 AM to 1:30 PM on day 3, after the freeze treatment ended. Equipment consisted of two Hasselblad cameras, each with a 1.94 inch (50 mm) lens. One camera held 2.76-inch (70 mm) Kodak Ektachrome MS Aerographic film, type 2448, (conventional color), and the other held 1.94-inch (50 mm) Kodak Aerochromo color infrared film, type 2443. (Mention of company or trademark is included for the reader's benefit and does not constitute endorsement of a particular product listed by the U. S. Department of Agriculture over others that may be commercially available.) No filters were used with either film.

A Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment, was used to measure total diffuse reflectance on upper (adaxial) surfaces of single leaves over the 0.5- to 2.5-um waveband. Data were corrected for decay of the barium sulfate standard (1) to give absolute radiometric data.

Leaf thickness was measured with a linear-displacement transducer and digital voltmeter (4). Water content of leaves was determined by ovendrying at 68 C (154 F) for 48 hr, cooling in a desiccator, and weighing. Total chlorophyll (5) was determined on leaf samples stored for 4 days at -15 ± 0.9 C (5 F ± 1.7 F).

Seven wavelengths were selected from the 41 wavelengths measured at 0.05-um increments over the 0.5 to 2.5-um waveband. Wavelengths selected were 0.55, 0.65, 0.85, 1.45, 1.65, 1.95, and 2.2-um; representing, respectively, the green reflectance peak, chlorophyll absorption band, a wavelength on the near-infrared plateau, the 1.45-um water-absorption band, the 1.65-um peak following the 1.45-um water-absorption band, the 1.95-um water-absorption band, and the 2.2-um peak following the 1.95-um water-absorption band.

The t-test (9) was used to test statistically differences between means of reflectances for frozen and non frozen leaves at each of the seven wavelengths.

RESULTS AND DISCUSSION

The reflectance of the water-soaked appearing, frozen sour orange leaves was significantly lower ($p = 0.01$) than nonfrozen leaves from 1 to 4 hr after the end of the freeze treatment for the 0.55-, 0.85-, 1.45-, 1.65-, 1.95-, and 2.2-um wavelengths (Fig. 1A) which agreed with results of a previous report (11). Frozen leaves had about 15 percentage points less near-infrared light (0.75 to 1.35 um) reflectance than nonfrozen leaves within 5 hr after the freeze treatment. Apparently, freezing destroyed the semi-permeability of cell membranes, and intercellular air was replaced by cell sap (2, 8). This greatly increased their transmittance and reduced their reflectance, as demonstrated by the vacuum infiltration of leaves with liquids (3). Frozen leaves were thinner than nonfrozen leaves, apparently because their cell turgidity decreased (Table 1). As frozen leaves dehydrated as compared with non frozen leaves (Table 1), frozen leaf reflectance began to increase about 24 to 27 hr after the freeze treatment (Fig. 1B). Frozen leaf reflectance significantly exceeded ($p=0.05$) nonfrozen leaf reflectance, except at the 0.85-um wavelength, from 48 to 51 hr after the freeze treatment. The chlorophyll concentrations of frozen leaves were not lower than that of nonfrozen leaves, until about 27 hr after the freeze treatment. From 48 to 51 hr after the freeze treatment, frozen leaves were essentially devoid of chlorophyll.

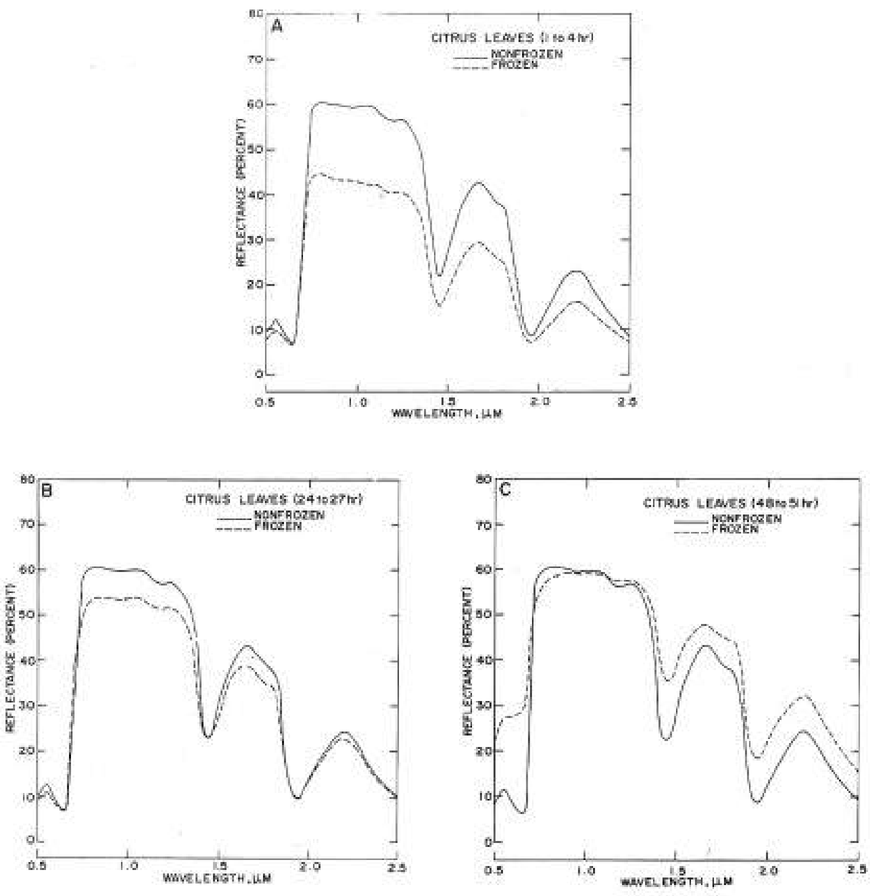

Fig. 1. Reflectance of frozen and non frozen sour orange leaves over the 0.5- to 2.5-um waveband from 1 to 4 hr (A), from 24 to 27 hr (B), and from 48 to 51 hr (C) after the freeze treatment ended.

Table 1. Mean water content and leaf thickness of nonfrozen and frozen sour orange leaves at five sampling times (hours after treatment).

	Water content			Leaf thickness		
Hours after treatment	Nonfrozen	Frozen	Nonfrozen-frozen	Nonfrozen	Frozen	Nonfrozen-frozen
	%	%	%	mm	mm	mm
1 to 4	61.1	62.1	-1.0	0.223	0.150	0.073*
6 to 9	60.2	61.2	-1.0	0.219	0.135	0.084*
11 to 14	60.3	57.6	2.7*	0.220	0.143	0.077*
24 to 27	60.1	51.3	8.8*	0.229	0.142	0.087*
48 to 51	59.8	41.2	18.6*	0.232	0.134	0.098*

*Significant at the 5% probability level.

Infrared and conventional color photographs did not show any difference in leaf appearance between frozen and nonfrozen sour orange plants, until about 30 hr after the freeze treatment, when the dehydration of frozen leaves was apparent visually and spectrally. Therefore, reflectance measurements may be better than infrared and conventional color photographs for detecting early freeze damage to sour orange plant leaves.

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Infrared Color Film Exposed With Red Light Shown To Be Best For Distinguishing Yellow Fruit Of Orange Trees From Green Leaves

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ABSTRACT

Ground-based photographs using several film-filter combinations and types of films without filters were taken of orange trees [*Citrus sinensis* (Linn.) Osbeck] with yellow fruit to determine the best way to distinguish the fruit from leaves. Underexposure of infrared color film at a norrow waveband of red light, 600 to 750 nm, gave a striking contrast between bright fruit and dark foliage.

The U.S. Department of Agriculture Statistical Reporting Service investigated the use of ground-based photography to forecast orange and grapefruit yields in selected groves in the lower Rio Grande Valley of Texas (1, 2). They found that estimated fruit yield per tree correlated highly with photographic counts for all types of citrus fruit studied. Escobar et al. (3) reported that conventional color film was better than infrared color film with a yellow filter for distinguishing grapefruit from foliage, when the fruit was rapidly changing from green to yellow. They suggested that conventional color ground-based photography might be used to rapidly and accurately estimate fruit yields.

In this study, we used several film-filter combinations and films without filters to determine the best waveband to distinguish yellow citrus fruit from leaves.

MATERIALS AND METHODS

We used three Hasselblad cameras, each with an 80 mm lens, to take ground-based photographs of orange trees with yellow fruit. Camera no. 1 had 70-mm Kodak Ektachrome MS Aerographic film 2448 (conventional color); camera no. 2 had 70-mm Kodak Aerochrome film 2443 (infrared color); and camera no. 3 had 70-mm Kodak Aerographic film 2424 (infrared black and white). (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U.S. Department of Agriculture over others that may be commercially available.)

Each camera was used with no filter and with each of the following filters: Kodak filters 92, 93, and 94; Tiffen Photar filters 87C, and 89B; and three Spectral Data infrared blocking filters (designated 'A', 'B', and 'C'). In addition, we also used the following Kodak filter and Spectral Data infrared blocking filter combinations: 92 + 'C', 93 + 'B', and 94 + 'A'. At aperture setting of f/8, we took photographs at shutter speeds of 1/30, 1/60, 1/125, 1/250, and 1/500 sec, at a distance of 12-m from the tree.

A Beckman Model DK-1A ratio recording spectrophotometer, equipped with a reflectance attachment, was used to measure transmittance of each filter and each filter combination over the 400- to 900-nm waveband.

Using a Richard's light table, equipped with a Bausch and Lomb Zoom 70 power pod, we compared positive 2443 and 2448 and negative 2424 film transparencies to determine which film-filter combination most effectively distinguished yellow fruit from leaves. We used number code scale of 0, 1, 2, 3, and 4 to represent zero, poor, fair, good and excellent distinction, respectively, between fruit and leaves on each of the film transparencies.

RESULTS AND DISCUSSION

The infrared color (2443) film with the 92 + 'C' filters was chosen as the best combination for distinguishing fruit from leaves (Table 1). Transparencies from

Table 1. Comparison of film-filter combinations.

Filter or filter combination	2448 Conventional color film	2443 Infrared color film	2424 Infrared black/white film
None	3*	1	0
'A'	2	2	1
'B'	2	1	1
'C'	3	1	2
94	0	0	0
93	0	0	0
92	0	3	0
94 + 'A'	0	0	0
93 + 'B'	2	0	0
92 + 'C'	3	4	3
89 B	0	0	0
87 C	0	0	0

* The number code scale of 0, 1, 2, 3, and 4 represents zero, poor, fair, good and excellent distinction, respectively, between fruit and leaves.

this film-filter combination, particularly those that were underexposed (f/8 at 500) were rated as excellent because the fruit appeared like illuminated electrical light bulbs against the tree's dark background, as shown in a black and white print (Fig. 1) made from the original transparency. However, several fruit that could be seen on the transparency are not evident on the print.

Fig. 1. A black and white print, made from the original transparency of the best film-filter combination, shows the fruit like illuminated electrical light bulbs against the trees dark background. (Several fruit that could be seen on the transparency are not evident on the print.)

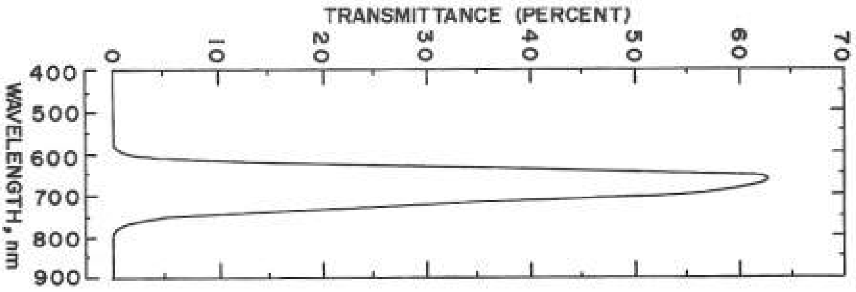

Fig. 2. The light transmittance of the 92 + 'C' filter combination over the 400- to 900-nm waveband.

Figure 2 shows the light transmittance of the 92 + 'C' filter combination over the 400- to 900-nm waveband, the sensivity range of infrared film (4). Transmittance occurred over a relatively narrow 600- to 750-nm waveband (red light) and peaked at the 670-nm wavelength, which corresponds with the chlorophyll absorption band. Therefore, the effectiveness of this filter combination was apparently related to a greater reflectance of red visible light by the yellow fruit (low chlorophyll concentration) than by green leaves (high chlorophyll concentration) (3).

These results showed that a narrow waveband (600 to 750 nm) in the red visible light portion of the spectrum in conjunction with infrared color film was best for distinguishing yellow fruit from leaves of orange trees. This photographic technique could facilitate using an electronic counter to determine the number of fruit on photographs of orange tree canopies.

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Use of LANDSAT-1 Data to Distinguish Grapefruit from Orange Trees and Estimate Their Hectarages

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ABSTRACT

Our objective was to determine if Earth Resources Technology Satellite (LANDSAT-1) multispectral scanner (MSS) data could be used satisfactorily to distinguish between Ruby Red grapefruit (*Citrus paradisi* Macf.) and orange [*Citrus sinensis* (L.) Osbeck] citrus varieties and to estimate their hectarages. Accordingly, LANDSAT-1 MSS data for a December 11, 1973, overpass (scene I.D. 1506-16293) were used in conjunction with Productive Properties' 600-ha citrus farm in Hidalgo County, Texas. Computer-aided variety classification accuracies for the farm with MSS data were 83, 91, and 86% for Rubyred grapefruit, orange, and total hectarages, respectively. The percentage comparisons of computer and farm manager's farm inventory estimates for Rubyred grapefruit, orange, and total hectarages were 17.3% underestimate, 14.3% overestimate, and 2.4% underestimate, respectively. These classification and hectarage comparison accuracies indicated that there is a good potential for computer-aided inventories of grapefruit and orange citrus orchards with satellite MSS data. This projected use will become more realistic with further refinements in MSS ground resolution, and data acquisition and processing.

Successfully identifying citrus varieties by remote sensing from aircraft or spacecraft would greatly facilitate updating citrus hectarage and tree population surveys (1). Some citrus varieties have been distinguished by their appearance on infrared color photos taken from aircraft (4). Moreover, different citrus-planting densities have been identified with infrared color photos taken from SKYLAB (5).

We conducted this study to determine if Earth Resources Technology Satellite (LANDSAT-1, formerly ERTS-1) multispectral scanner (MSS) data could be used satisfactorily to distinguish between grapefruit and orange citrus varieties and to estimate their hectarages.

MATERIALS AND METHODS

Computer compatible digital tapes (CCT) for LANDSAT-1 four-band MSS were obtained for the December 11, 1973, overpass of the Productive Properties, Inc. citrus farm located northwest of Edinburg in Hidalgo County, Texas. The farm has about 600 ha with five citrus varieties: Rubyred grapefruit (*Citrus paradisi*

Macf.) and Valencia, Marrs, Hamlin, and Navel oranges [*Citrus sinenis* (L) Osbeck]. A ground truth map showing the location, hectarage, and content of citrus orchards within the farm in 1973, was obtained from the farm manager in order to test the validity of the computer aided citrus inventory of the farm.

A line printer graymap was generated of an area, including the citrus farm, using digital data differences between MSS band 5 (0.6 to 0.7 um) and 7 (0.8 to 1.1 um). The farm manager's ground-truth map was used to delineate the citrus orchards within the farm on the graymap. The CCT data record and picture element data sample (pixel) coordinates of about half of the Rubyred, Hamlin, Valencia, Navel, and Marrs citrus training orchards were determined from their locations delineated on the graymap, and the digital data from these citrus orchards were selected from the CCT to train a computer-aided crop classifier (IBM 1800). (Mention of company or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U. S. Department of Agriculture over others that may be commercially available.) We used this classifier to classify all the digital count data within the farm into orange (Hamlin, Valencia, Navel, and Marrs training orchards) and grapefruit (Rubyred training orchards) hectarage inventory categories. All idle cropland, young citrus, and water body categories were classified into a threshold (unknown) category. To classify these data we used as the computer-aided methods a maximum likelihood classifier (3) implemented with a table look-up procedure (2).

The results of the computer-aided survey of the citrus orchards within the farm were summarized by a line-printer classification map and a hectarage-inventory classification table (Table 1). The classification map indicated the distribution of orange and grapefruit orchards throughout the farm with respect to the actual orchard's boundaries delineated on the classification map. From the classification map, the number of pixels classified as oranges, grapefruit, and threshold by the computer-aided classification procedures, within the boundaries known to be oranges and grapefruit, were counted and a hectarage inventory classification table was developed to determine the computer classification accuracy.

RESULTS AND DISCUSSION

Figure 1 shows pictorial comparisons of black-and-white renditions of a LANDSAT-1 color composite and an aerial infrared color photo of the citrus farm, and a printout classification map of the farm. Table 1 shows a comparison of the farm manager's and computer-aided inventory hectarage estimates of grapefruit and orange citrus orchards on the Productive Properties, Inc. citrus farm. The interpreter's pixel count of computer-generated graymaps resulted in estimates of farm hectarages that compared with the farm manager's hectarages estimates as follows: Grapefruit hectarage was underestimated by 3.2% (308 vs 318 ha), orange hectarage was overestimated by 3.0% (244 vs 237 ha), and total hectarage was underestimated by 0.5% (522 vs 555 ha).

Table 1. Farm manager's and computer-aided inventory of grapefruit and orange citrus orchards located on the Productive Properties, Inc., citrus farm for a December 11, 1973, LANDSAT-1 overpass. Areas with idle cropland, young citrus and water bodies (76 ha) form a threshold category for the maximum likelihood classifier because the computer was trained to classify mature citrus spectra. Photo interpreter's graymap pixel identities are judged against farm manager's ground truth.

Citrus variety categories	Farm manager's estimate from ground truth	Interpreter's estimate from graymap pixel count	Percent correct classification	Computer estimate from maximum-likelihood classifier		
				Grapefruit	Oranges	Threshold
	ha	ha	%	ha	ha	ha
Grapefruit	318	308	82.5[1]	254[2]	48[3]	6[4]
Oranges	237	244	91.4[5]	17[6]	223[7]	4[8]
Overall	555	552	86.4[9]	271[10]	271[11]	10[12]

1 Percent correct classification for grapefruit = 254 ha/308 ha X 100% = 82.5%.
2 Grapefruit hectarage computer correctly identified as grapefruit.
3 Grapefruit hectarage computer incorrectly identified as oranges.
4 Grapefruit hectarage not identified as either grapefruit or oranges by computer.
5 Percent correct classification for oranges = 223 ha/244 ha X 100% = 91.4%.
6 Orange hectarage computer incorrectly identified as grapefruit.
7 Orange hectarage computer correctly identified as oranges.
8 Orange hectarage not identified as either grapefruit or oranges by computer.
9 Overall correct classification = (254 ha + 223 ha)/552 ha X 100% = 86.4%.
10 Overall computer grapefruit hectarage estimate (254 ha + 17 ha = 271 ha).
11 Overall computer orange hectarage estimate (48 ha + 223 ha = 271 ha).
12 Overall computer hectarage estimate that is not either grapefruit or oranges (6 ha + 4 ha = 10 ha).

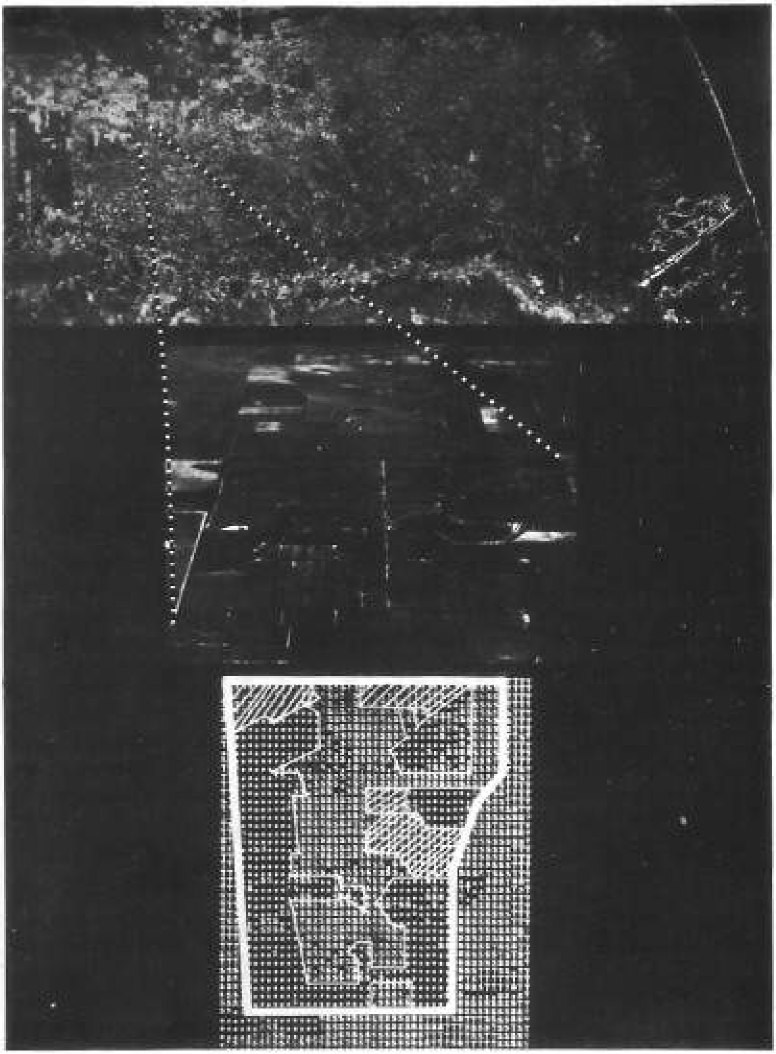

Fig. 1. The upper picture is a black-and-white rendition of a LANDSAT-1 color positive print composite [MSS bands 4, 5, and 7 from an overpass for December 11, 1973, (ID-1506-16293)] of the Lower Rio Grande Valley of Texas showing the location of the Productive Properties, Inc., citrus farm by dashed lines. The middle picture is a black-and-white rendition of a close-up oblique infrared color photograph (positive print) of the farm taken on September 22, 1975, at 3048 m altitude. The lower picture is a computer printout classification map from the LANDSAT-1 data of the citrus farm showing the localized areas of grapefruit (•), oranges ($), water bodies and bare soil (/), and unknown category (T). Middle and lower pictures are delineated for comparison.

If the maximum likelihood classification procedures were 100% accurate in their classification, then the computer hectarage estimates would equal the interpreter's hectarage estimate for the farm. However, classification accuracies were 83, 91, and 86% for grapefruit, orange, and total, respectively (Table 1). These classification accuracies yielded computer-estimated hectarage estimates of the farm that compared with the farm manager's hectarage estimate as follows: Grapefruit hectarage was underestimated 17.3% (271 vs. 318 ha), orange hectarage was overestimated 14.3% (271 vs. 237 ha), and total hectarage was underestimated 2.4% (542 vs. 555 ha). The computer-estimated hectarage depends on both the hectarage correctly and incorrectly classified as a specific category, and on threshold classifications (footnotes 10 and 11, Table 1).

Results comparable with those of December 1973, for oranges and grapefruit, were obtained for a May 1973, LANDSAT-1 overpass. However, Richardson et al. (1976) showed that citrus could be satisfactorily distinguished from other crops only during the winter months in Hidalgo County, Texas.

Even though these computer classification accuracies were not high enough to yield computer hectarage estimates equal to the interpreted or farm manager's, they were high enough to be useful for computer-aided inventories of orange and grapefruit citrus orchards. However, this projected use will become more realistic with further refinements in satellite MSS ground resolution and data acquisition and processing.

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We thank Mr. Duane Doss, Farm Manager, Productive Properties, Inc., for his help.

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Native Potato Tree (*Solanum erianthum* D. Don)
Grown As An Ornamental

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ABSTRACT

The potato tree, a shrub or small tree belonging to the nightshade family, is a member of the native flora of the Lower Rio Grande Valley of Texas. However, it is threatened with extinction because the valley is being extensively cleared of native vegetation to provide growing area for agricultural crops. It is grown as an ornamental and should be maintained as a member of our native flora.

The potato tree, also known as Salvadora, is a shrub or small tree of the nightshade family: Solanaceae. It reaches a maximum height of about 10 ft, has broad leaves 4 to 12 inches long (Fig. 1), and bears small white flowers that produce small green berries which turn yellow at maturity (2).

Fig. 1. Photograph of the leaves, flowers, and fruit of the potato tree.

The potato tree is a member of the Lower Rio Grande Valley's native flora, but is a rare species. With the extensive bulldoze-clearing of native brushland to obtain more growing area for agricultural crops, this plant is threatened with extinction. The only location where this species is still known to grow naturally in the Lower Rio Grande Valley is in a few remaining blocks of native brushland on the banks of Resaca Vieja near Olmito, Cameron County, Texas. This species is found through tropical and subtropical America, but in the United States it is native only in extreme south Texas and southern and south central Florida (1).

Three potato tree seedlings were taken from the Olmito location (fall 1974) and transplanted to pots in a greenhouse at the U.S. Department of Agriculture laboratory in Weslaco, Texas. After a few months (spring 1975), they were again transplanted to my residence in Weslaco. These plants have flourished and are now 6 to 7 ft. tall and have flowered and produced many seeds. Many young trees have been grown from these seeds and transplanted to other residences in Hidalgo County, Texas. Seedlings have been transplanted to the Santa Ana National Wildlife Refuge, south of Alamo, Texas, to help maintain the potato tree as a member of our native flora.

Hopefully, the potato tree will remain a member of our native flora and become an unusual ornamental in the Lower Rio Grande Valley of Texas.

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Yield, Growth Characteristics, and Oil Composition of Four Hybrid Sunflower Cultivars

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ABSTRACT

Yield, growth, and oil characteristics were determined for four spring planted hybrid sunflower cultivars (Sunbred 212, Romsun 52, Sun Gro 380, and Sun Gro 372) in the Lower Rio Grande Valley of South Texas.

Yields ranged between 1,706 and 2,259 kg/ha. Sun Gro 372 yielded significantly less than for the other cultivars. Sunbred 212 was earlier and more uniform in bloom than the other cultivars which reduced the time interval that the crop was exposed to head moth and bird damage. Spring planted sunflowers were higher in oleic (55.5%) than in linoleic (36.2%) fatty acid; the opposite was observed for the fall-planted crop that matured in December for which the oleic and linoleic fatty acid contents were 15.8 and 72.8%, respectively.

The demand for edible oils and protein sources has led to the development of a viable sunflower (*Helianthus annus* L.), industry in the United States. Successful production of sunflowers on the High Plains of West Texas in 1974 spurred interest in sunflower production in the Lower Rio Grande Valley of South Texas (LRGV). This area's proximity to seaports, crushing facilities (cotton oil mills), and long growing season (versatility in planting dates and irrigation requirements) make sunflowers a possible economic crop in LRGV agriculture.

Studies have been conducted on management and cultural aspects of sunflower production in other countries (10, 11). In these studies, row configurations had less influence on yield and growth characteristics than did plant populations. Plant populations between 56 to 98 thousand plants/ha resulted in highest yields. Soil-water stress affected yield, oil content, and the ratio of the unsaturated acids (oleic/linoleic acids) (2, 3, 9). In the LRGV, seed yields of four fall-planted (August) sunflower strains were 1,443 to 1,796 kg/ha in 1974. The average oil content of the same species was 43.1% and contained a high percentage of unsaturated linoleic acid (1).

The purpose of this study was to compare yields, oil contents, and growth characteristics of spring plantings of four sunflower hybrids.

MATERIALS AND METHODS

Four hybrid sunflower cultivars (Sunbred 212, Romsun 52, Sun Gro 380 and Sun Gro 372) were planted March 7, 1975 (spring-planted), at the Soil and Water

Conservation Research Farm, Weslaco, Texas. The experiment was a randomized complete block design with four replications. Each plot consisted of eight rows 15 m long. The soil type is a Hidalgo fine sandy loam. Plots were hand-thinned to 69 thousand plants/ha. Sixty-seven kg/ha of N (as urea) was sidedressed when the plants were 25 cm tall. Eight m of two rows were harvested on June 16, 1975. The seed heads were hand-cut, air-dried, and threshed. The final weights were adjusted to 10% moisture. A 7-day spray schedule with methyl parathion (1.12 kg/ha) was initiated at first bloom for the control of head moth (*Homoeosoma electellum* Hulat) and *Suleima helianthana* Riley. The Sunbred 212 plots received two sprayings, and the other cultivars received three sprayings for the control of head moth (*Homoeosoma electellum* Hulat) and *Suleima helianthana* Riley. The plots received two post-emergence irrigations.

For oil analyses, sunflower seeds were washed with a 1% sodium hypochlorite solution, rinsed with distilled water, and placed in a 60 C oven. Dried Hyflo Super Cell (50 g) was added to each seed sample for grinding on a standard laboratory Wiley mill. Four grams of the resultant mixture were placed in a cellulose soxlet extraction thimble. The thimble was placed in a soxlet apparatus for extraction with petroleum ether. The moisture and volatile matter were determined by drying the seed sample to constant weight. After drying, 3 to 4 mg of oil were transesterified using a methanolic-base reagent. The mixture of esterified fatty acids was evaporated to dryness over anhydrous sodium sulfate. Fatty acid compositions of the oil were determined with a gas chromatograph equipped with a flame ionization detector (4, 5, 6, 8).

RESULTS AND DISCUSSION

Table 1 shows sunflower seed yields for all four hybrid cultivars which ranged from 2,259 to 1,706 kg/ha. Sun Gro 372 yielded significantly less than did the other cultivars. However, yields from this study were higher than those obtained by area sunflower growers. They were planted in January and had serious bird depredation; whereas, in this study, the maturity of the sunflowers coincided

Table 1 .Yield and plant growth characteristics for four hybrid sunflower cultivars planted in the Lower Rio Grande Valley.

Cultivar	Yield	Days to bud	Number of nodes to bud	Plant height	Head diameter
	kg/ha			cm	cm
Sunbred 212	2,259 a[1]	45 a	19 a	170 ab	16.7 a
Sun Gro 380	2,139 a	49 b	20 ab	179 a	15.1 a
Romsun 52	2,204 a	49 b	20 b	164 b	17.0 a
Sun Gro 372	1,706 b	51 c	22 c	179 a	16.1 a

[1] Numbers in the same column followed by the same letter are not significantly different at the P .05 level, as determined by Duncan's multiple range test.

with grain sorghum, thereby dispersing the birds' depredation over a much larger crop area.

The number of days from planting to flower bud, which is an indication of the earliness of the cultivar, was significant among cultivars (Table 2). Sunbred 212 reached the flower bud stage of growth in 45 days as compared with 49 days for Sun Gro 380 and Romsun 52, and 51 days for Sun Gro 372. The Sunbred 212 flower bud occurred at a significantly lower node (19th) on the plant than for Romsun 52 and Sun Gro 372, which had buds at the 20th and 22nd nodes, respectively. Plant height also varied among the four cultivars. Romsun 52 was the shortest, and Sun Gro 372 the tallest. Head diameters ranged from 15.1 to 17.0 cm with no significant differences among cultivars.

Table 2. Percent of plants in yield rows of the four cultivars that had bloomed by May 12, 15, and 22, respectively.

	Bloom		
Cultivars	5/12	5/15	5/22
		%	
Romsun 52	31 b[1]	49 b	91 a
Sun Gro 372	1 c	9 d	85 a
Sunbred 212	85 a	93 a	99 a
Sun Gro 380	30 b	33 c	95 a

[1] Numbers followed by the same letter within each column do not differ significantly at the P .05 level, as determined by Duncan's multiple range test.

The earliness and uniformity of bloom is shown in Table 2. On May 12, 85% of the Sunbred 212 plants were in bloom as compared with 30% (Sun Gro 380), 31% (Romsun 52), and 1.3% (Sun Gro 372), respectively. Earliness and uniformity for time of bloom are both important in decreasing the number of spray applications, and for decreasing the time interval that the crop is exposed to bird and other enviromental hazards.

Seed analysis data are presented in Table 3. Romsun 52 had a significantly greater N content (3.1%) than did the other cultivars. Protein contents ranged from 17 to 22.8% with an average of 19.1%. Romsun 52 had the lowest oil content (46.2%) which was significantly lower than the other cultivars. Sunbred 212 had the highest oil content (49.2%) but did not differ significantly from either Sun Grow 372 or Sun Grow 380.

Spring-planted sunflowers matured when minimum and maximum temperatures were 22.4 to 32.2 C, respectively, for 30 days before harvest. The seed of all cultivars were higher in oleic than linoleic acids. The average fatty acid content for all cultivars was 55.5% for oleic and 36.2% for linoleic. In 1974, fall-planted sunflowers maturing in early December had about 70% linoleic and 18% oleic acid, or the reverse of that observed for these spring-planted sunflowers (1).

Table 3. Analysis of seed from four sunflower cultivars.

Cultivars	Nitrogen	Protein	Oil	Fatty acids			
				Palmitic	Stearic	Oleic	Linoleic
	%						
Romsun 52	3.1 a[1]	19.0 a	46.2[2]b	5.1 a	2.9 b	53.7 b	38.3 a
Sun Gro 372	2.9 b	17.6 ab	48.4 a	5.4 a	3.0 ab	55.2 ab	36.4 ab
Sunbred 212	2.9 b	17.6 ab	49.2 a	5.1 a	3.3 a	58.3 a	33.3 b
Sun Gro 380	2.8 b	17.0 b	48.9 a	5.4 a	3.1 ab	54.9 ab	36.6 ab

1 Numbers followed by the same letter within each column do not differ significantly at the P.05 level, as determined by Duncan's multiple range test.

2 Dry wt basis.

These data agree with that of other researchers since these two fatty acids are environmentally controlled and are related to the temperatures during seed set and maturity. In some regions, the oil fatty acid composition may possibly be controlled by varying planting and harvesting dates.

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A Method For Estimating Grain Sorghum Yield Losses Due To Iron Chlorosis

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ABSTRACT

Our objectives were to determine the percentage of the acreage planted to grain sorghum in Hidalgo County, Texas in 1973, that was affected by iron (Fe) chlorosis and the effect of Fe chlorosis on the grain sorghum production of Hidalgo County in 1975.

For 1973, we aerially photographed three areas of Hidalgo County with Eastman Kodak color infrared film. We found that within these areas, 6,015 acres (28.6%) of the 21,038 acres of grain sorghum were affected by Fe chlorosis.

For 1975, we collected separate yield samples from areas of green (normal) and of yellow (chlorotic) grain sorghum plants within each of 10 commercial sorghum fields. The average yield difference between normal and chlorotic yield samples was 1,802.0 lb./acre, with an average yield decrease of 603.1 lb./acre.

The decrease in grain yields on a per field basis was determined first by yield differences between normal and chlorotic areas, and second by the percentage of the field affected by Fe chlorosis.

Grain sorghum [*Sorghum bicolor* (L.) Moench] is one of the annual crops grown in south Texas, that is most sensitive to iron (Fe) deficiency (chlorosis) (6). This deficiency symptom is easily identified since chlorotic leaves are yellow with dark-green veins (1, 7). The interveinal chlorosis (striping) extends the full length of the blades. Sometimes, leaves are yellow with white tips. When Fe deficiency is very severe, plants are white, stunted, and sometimes they die.

In 1975, 300,000 acres of the 2-million acres planted to grain sorghum in the Rio Grande Valley-Coastal Bend area of south Texas were deficient in available Fe (10). An estimated 12-million acres (5%) of all the cultivated acres in the 22 western states are deficient in available iron (8).

Chlorotic areas in grain sorghum fields are easily detected with Eastman Kodak color infrared aerial photographs taken from aircraft (2) or spacecraft (3). (Mention of company or trademark is included for the readers' benefit and does not constitute endorsement of a particular product listed by the U.S. Department of Agriculture over others that may be commercially available.) This photography can be used for surveying large areas to determine acreages of chlorotic grain sorghum (3), and to show farmers sorghum areas that require foliar applications of Fe (5) to attain maximum yields.

We conducted this study to determine the percentage of the acreage planted to grain sorghum in Hidalgo County, Texas, that was affected by Fe chlorosis in 1973 using color infrared photography and to calculate the effect of Fe chlorosis on grain sorghum production of Hidalgo County in 1975.

MATERIALS AND METHODS

In April 1973, three areas planted predominantly to grain sorghum every year and had fields with green (normal) and yellow (chlorotic, Fe deficient) grain sorghum plants were chosen in Hidalgo County, Texas. These three areas were configured and located as follow: a 3.4- x 27.0- mile area along farm to market (FM) road no. 490 between McCook, Texas, and the west levee of Delta Lake; a 3.4- x 30.0- mile area along FM road no. 1925 between FM road no. 681 and the Hidalgo-Cameron County Line; and a 3.4- x 15.0- mile area along State Highway no. 186, between U.S. Highway no. 281 and FM road no. 1015. These areas covered a total of 224.8 square miles.

The three areas were photographed when the sorghum plants were in the preboot and boot growth stages, by exposing Eastman Kodak Aerochrome color infrared (CIR) film 2443 at f-stop 5.6 for 1/150 sec at an altitude of 12,000 ft above mean sea level during partly cloudy (10%) and medium-haze conditions, between 2:30 and 4:00 pm CDT on May 11, 1973. A Zeiss 9- X 9-inch format RMK 15/23 camera was used, equipped with a 6-inch focal length lens with a 15 G-30 magenta-filter-combination placed over the lens aperture.

Acres within each field occupied by normal and chlorotic sorghum plants were determined from the 9- x 9-inch CIR film transparencies. The film image of each field was overlaid with a grid system, and the grid squares corresponding to areas of normal and chlorotic sorghum plants were counted separately to determine the percentages for normal and chlorotic areas.

A multiplier for converting grid squares to acres was determined by field measuring and calculating the acreage for each of five fields. The number of grid squares from above were ratioed to the number of acres for each field. An average of the five grid square-acres ratios was determined and used as the multiplier to convert grid squares for normal plants, for chlorotic plants, and for each field to acres.

In June 1975, 10 commercial grain sorghum fields that contained areas of normal and chlorotic plants were selected. A normal and a chlorotic area in each field was sampled for yield by harvesting the heads from all plants along one 17-ft long bed. Heads were placed in woven plastic bags, and taken to a greenhouse for air drying. After drying, the seeds were removed from the straw with a plot thresher and weighed.

On June 2 and 3, 1975, between 12:00 and 1:00 p.m. CDT, the 10 commercial sorghum fields were photographed aerially by exposing CIR film at f-stop 8.0 for 1/250 sec 8,000 ft above mean sea level, during cloudless and medium-haze conditions. A Hasselblad 500EL camera was used, equipped with an 80-mm lens with a 2X, CB6, 40X Hasselblad-filter-combination placed over the lens aperture.

The areas in each field occupied by normal and chlorotic sorghum plants were determined with an Instrumentation System Inc. VP-8 image analyzer, equipped with an electronic digital display planimeter (4). The linear correlation of yield differences (normal - chlorotic areas) with potential yield (assuming all areas normal) was calculated (9).

Potential yields were calculated as yield of normal plant samples (lb/acre) multiplied by the number of acres in the field.

RESULTS AND DISCUSSION

From the 1973 CIR aerial photography of the three areas within Hidalgo County we determined that 6,015 acres (28.6%) of the 21,038 acres planted to grain sorghum had chlorotic sorghum plants. In 1973, 325,000 acres of land in Hidalgo County were planted to grain sorghum. Using the percentage of Fe chlorosis determined from the 1973 aerial survey and after adjusting for areas within the county where Fe chlorosis was almost non-existent (10), we estimated that for 1973, 83,675 (25.7%) acres of grain sorghum plants were affected by Fe chlorosis.

The data for 10 commercial grain sorghum fields sampled for yields of normal and chlorotic plants during the 1975 growing season are presented in Table 1. Average sample yield for normal plants was 2,533.9 lb./acre (Table 1), which was lower than the 3,419.0 lb./acre reported by the Texas Crops and Livestock Reporting Service (TCLS, personal communication). This difference was probably caused by the fact that we only sampled fields with chlorotic plants, and that normal plant yields in these fields may have been lower than that of fields where sorghum plants were not visually affected by Fe Chlorosis.

The percentage of the field occupied by chlorotic plants ranged from 18% for field no. 5 to 53.3% for field no. 10, with an average of 33.2%. Yield differences between normal and chlorotic plants within a field ranged from 55 lb./acre for field no. 9 to 3,104 lb./acre for field no. 6, with an average sample yield difference of 1,802 lb./acre.

To assess the effect of Fe chlorosis on grain sorghum yields for 1975, we determined the difference between potential (normal) and actual (normal + chlorotic) yields for each field. These differences showed that field yield reductions caused by Fe chlorosis ranged from 11 lb./acre for field no. 9 to 1,188 lb./acre for field no. 10, with an average yield reduction for the 10 fields of 603.1 lb./acre (Table 1).

Table 1. Ten commercial grain sorghum fields in Hidalgo County in 1975: their total and chlorotic acreage, and average sample and field yields.

Field	Total acreage	Chlorotic acreage	Sample yield[1]			Field yield[2]		
			Normal plants	Chlorotic plants	Decrease	Normal[3]	Actual[4]	Decrease
No.	Acres	%	lb./acre			lb./acre		
1	15.32	19	926.0	327.0	599.9	926.0	812.0	114.0
2	13.59	49	762.0	218.0	544.0	762.0	495.0	267.0
3	18.04	40	2,559.0	436.0	2,123.0	2,559.0	1,709.0	850.0
4	27.18	35	3,049.0	599.0	2,450.0	3,049.0	2,192.0	857.0
5	29.90	18	2,886.0	218.0	2,668.0	2,886.0	2,317.0	569.0
6	39.29	20	3,757.0	653.0	3,104.0	3,757.0	3,136.0	621.0
7	30.15	31	3,321.0	653.0	2,668.0	3,321.0	2,494.0	827.0
8	51.15	46	2,723.0	1,143.0	1,580.0	2,723.0	1,996.0	727.0
9	39.04	20.4	2,505.0	2,450.0	55.0	2.505.0	2,494.0	11.0
10	4.94	53.3	2,831.0	599.0	2,232.0	2,831.0	1,643.0	1,188.0
Average		33.2	2,533.9	729.6	1,802.0	2,533.9	1,928.8	603.1

1 Weight of grain from one, 17-ft. long bed.
2 Yield calculated in the conventional manner.
3 Yields assuming all plants in the field were normal.
4 Yields including both chlorotic and normal plants.

We determined with linear correlation that yield decreases are determined primarily by yield differences between normal and chlorotic plants.

The TCLS indicated that for 1975, 331,300 acres of grain sorghum plants were harvested in Hidalgo County. When we applied the percent for acres of chlorotic plants determined for 1973, to total acres of grain sorghum plants harvested for 1975, we found that 85,297 harvested acres were occupied by chlorotic sorghum plants.

The 331,300 acres of grain sorghum harvested for 1975 had a potential production of 419,740 tons (acres X yield in tons/acre of normal plants), while the actual production was 342,790 tons (acres of chlorotic plants X yield in tons/acre + acres of normal plants X yield in tons/acre) of grain. This is a production loss of 76,950 tons or 18.3%.

CONCLUSION

For 1973, 6,015 acres (28.6%) of the 21,038 acres surveyed, were found to be occupied by chlorotic grain sorghum plants. For 1975, an average yield difference of 1,802.0 lb./acre was found between normal and chlorotic sorghum plants. In Hidalgo County for 1975, 85,297 of the 331,300 acres of grain sorghum harvested were chlorotic with a production loss of 76,950 tons (18.3%) of grain.

This study demonstrated a method whereby data from an aerial photographic survey could be combined with a minimum of ground (yield) data to determine the effect of Fe chlorosis on grain sorghum production. This method would be applicable to horticultural crops like the field bean which often has chlorosis.

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Narrow Trenches in a Vertisol (Harlingen Clay) Increased Cotton Root Development and Reduced Soil Salinity

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ABSTRACT

Narrow trenches backfilled with soil and positioned directly under cotton plant beds decreased soil salinity and increased lateral and vertical root distribution of cotton roots growing on Harlingen Clay.

Harlingen clay and related soils occupy approximately 60 thousand ha of the cotton producing area of the Lower Rio Grande Valley of Texas. These fine-textured soils have high shrink-swell potential, cracking extensively when dry. They are brownish calcareous clay to a depth of at least 125 cm with intersecting slickensides. Soil texture is relatively constant with depth.

Plant growth is severely limited in Harlingen clay. It has been observed that 99% of cotton roots are in the surface 20 cm of the soil profile (3). Because of limited root penetration, the soil water nutrients from lower depths are not used.

Soil salinity also contributed to limited crop production on this soil. The electrical conductivity generally exceeds 4 mmhos/cm at the 60- to 120-cm depth. Generally, production is limited for most crops when the electrical conductivity exceeds 4 mmhos/cm at the root zone. Exchangeable sodium which increases with depth usually ranges from 6% in the upper part of the solum to 25% in the C horizon (5). Irrigation water used averages about 800 ppm salt. Salt accumulation sufficient to retard seed germination and plant growth can occur in seedbeds in a growing season in the absence of rainfall.

Deep tillage has successfully improved soil-plant-relations on other clay soils throughout the United States. Increased root growth and penetration of corn roots have been obtained by mixing and fertilizing the soil profile to depths up to 90 cm (2). Moisture storage was increased on a Pullman silty clay loam by breaking up the dense B_2 horizon by disc plowing 60-cm deep (4).

The objective of this study was to determine if narrow trenches backfilled with soil and positioned directly under cotton plant rows would decrease soil salinity and increase cotton root distribution and depth on Harlingen clay.

EXPERIMENTAL PROCEDURES

Two trench treatments were compared with conventional tillage practices. Treatments were: conventional tillage (check); 10-cm wide x 60-cm deep trench, soil backfilled (shallow trench); and 10-cm wide x 100-cm deep trench, soil backfilled (deep trench). The experimental design was a randomized complete block with four replications. Each plot consisted of 6 rows, 30-m long.

A small, conventional trench-digging machine was used for making the trenching treatments. Trencher blades (9-cm wide) cut a trench 13-cm wide at the surface and 10-cm wide at the bottom of the trench. Beds were formed over the trenches (102-cm apart) and planted to cotton (*Gossypium hirsutum* L., Stoneville 7A) for 3 consecutive years (1970, 1971, and 1972). In 1973, the plots were seeded to sugarcane (*Saccharum officinarum* L.). Seedling emergence was assured by irrigating all plots at planting. A preemergency herbicide at the rate of 1.7 kg/ha was incorporated in the surface 1.2 cm of soil immediately after planting the cotton.

Salinity samples were taken periodically by auger cores from both rows and furrows to compare profile salinity changes. Cores were taken at depth increments of 0-to 15-, 15-to 30-, 30-to 45-, 45-to 60-, 60-to 90-, and 90-to 120-cm depth. Electrical conductivity was measured on saturated soil extracts with a wheatstone bridge.

The annual rainfall average for the study area is 58 cm. Soil moisture was determined in the row of every plot both by neutron probe and gravimetric sampling techniques. Plots were furrow irrigated when approximately 60% of available moisture in 0- to 60-cm depth was depleted.

All plots were sidedressed with 200 kg N/ha. Insecticides were applied by aerial spraying when necessary.

At the end of each season, three cylindrical cores (5 cm in diameter and 10 cm long) per plot to 120 cm depth were taken directly over the row and 15, 30, and 45 cm horizontally from the row (interrow area) to observe root penetration and distribution. The cores were subsequently waterwashed, roots were separated from soil, and the oven-dry weight of roots was obtained for selected depth increments (6).

Photographs of roots for recording differential root distribution of deep-trench and check treatments were taken from an excavated pit.

RESULTS AND DISCUSSION

Changes in cotton root distribution for the 3-year period were evident in both trench treatments. The objective of increasing plant root depth by trenching was achieved. The greatest cotton root penetration was observed in the deep trench (Fig. 1) where roots were well distributed to a depth of 120 cm. Roots growing under conditions of the check treatment were confined to a depth of 60 cm (Fig. 2). The soil matrix remained loosely held in the trench, providing for more rapid water intake and storage at depths less susceptible to evaporative losses. Stored moisture became available to the plants when roots penetrated deeper soil zone.

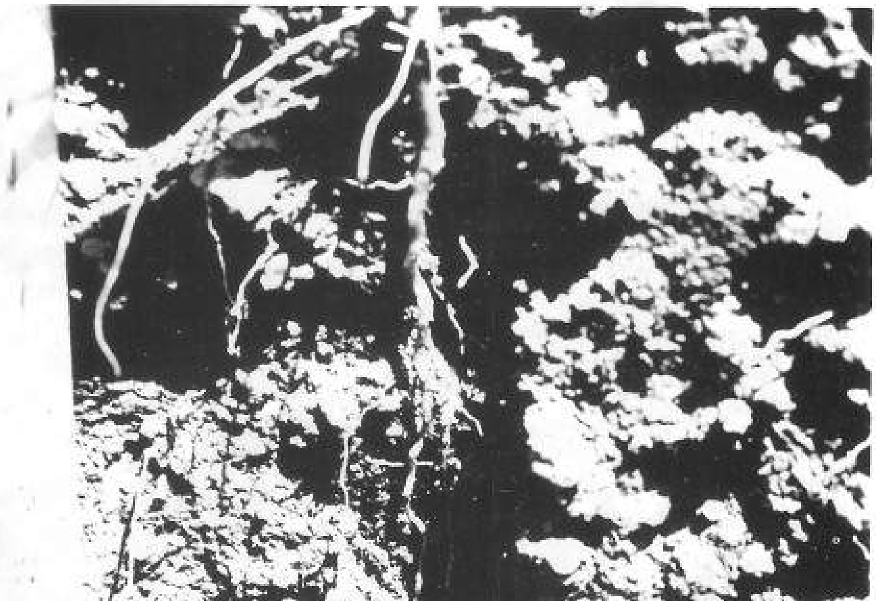

Fig. 1. Photograph of deep trench treatment showing distribution of cotton roots under the deep trenching treatment (Note the discontinuity in the soil matrix at the interface of trench and undisturbed soil.)

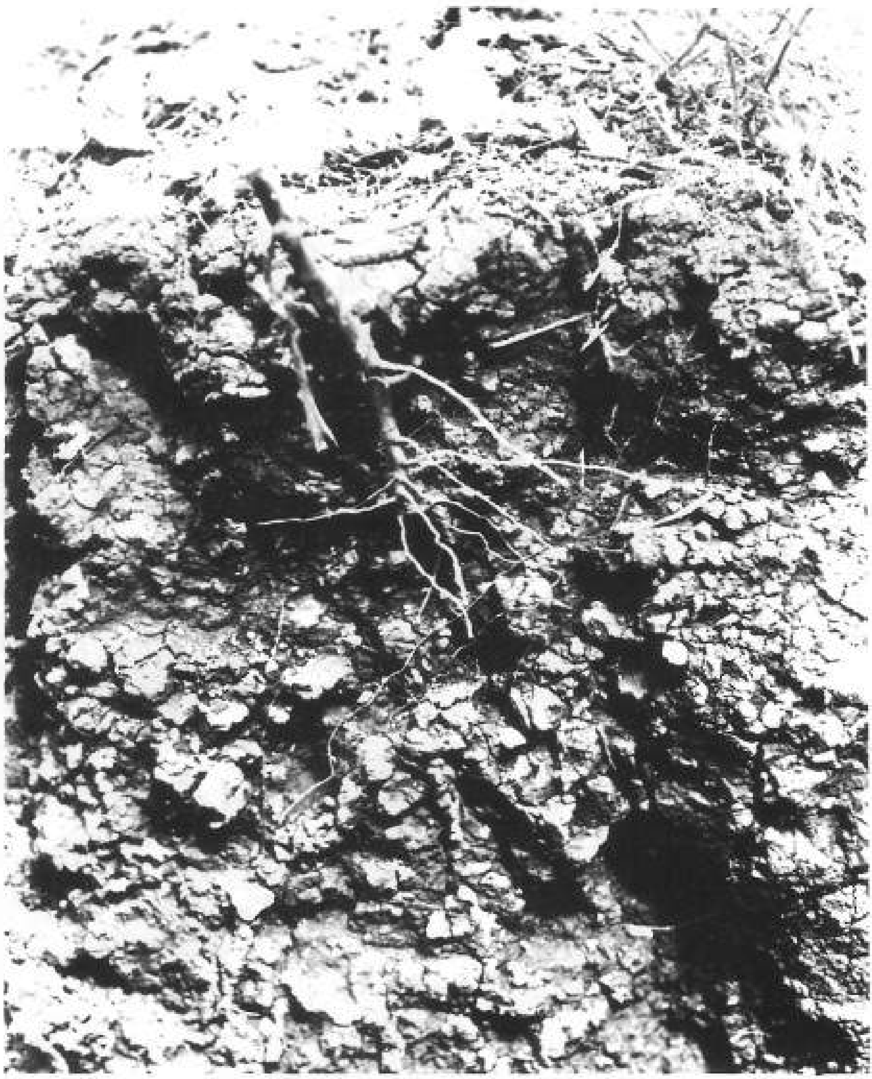

Fig. 2. Root penetration as observed from an open pit from cotton plants grown under conventional treatment.

The photograph for the check treatment (Fig. 2) shows more roots at the soil surface. These shallow roots depend on moisture from the upper soil profile. (Note the lateral movement of roots along the interface between disturbed and undisturbed soil created by plowing.) The concentration of roots resulted in rapid depletion of soil water by evaporation at this shallow depth. Visual observations showed that plants on the check treatment were of smaller size and wilted 4 to 5 days earlier than plants on the trench treatments. Check plots required an additional irrigation compared with the trenched plots.

The percentage of roots (dry weight) from the soil profile of the different treatments is shown in Table 1. Percentages of roots in the 0- to 30-cm depth were 82.5%, 43.8% and 43.3% for the check, shallow, and deep-trench treatments, respectively. The distribution of roots at the 0-to 30-cm depth for the check treatment was very uniform with horizontal distance from the trench. The check treatment only had 16.5% and 1.0% of the roots at the 30- to 60-cm and 60- to 90-cm soil depths, respectively. This poor root growth was probably related to poor aeration and high salinity at the deeper soil depths. Since most of the roots were in the upper 30 cm of soil, moisture and nutrients from lower depth were not used efficiently by plants. The shallow-trench treatment had 85.6% of total roots in the upper 60-cm depth, while the deep-trench treatment had 90.6% of total roots in the upper 90-cm depth.

The shallow and deep-trench treatments had a better horizontal and vertical distribution of roots than the check treatment because improved aeration existed in trenches. Large air voids were created by the ditching machine in the trenched areas. The machine made marble size clods that greatly reduced the bulk density of the soil in the trenched region.

Table 1. Effect of soil profile modification (trenches) and conventional treatments on depth and lateral distribution of cotton roots in a Harlingen clay soil in 1971.

Horizontal distance from trench	Sampling depth, cm			
	0 to 30	30 to 60	60 to 90	90 to 120
cm	% roots recovered			
	CHECK			
0	83.0	17.0	-	-
15	90.0	9.0	1.0	-
30	80.0	19.0	1.0	-
45	77.0	21.0	2.0	-
Mean	82.5	16.5	1.0	-
	SHALLOW TRENCH			
0	48.0	42.0	10.0	-
15	25.0	52.0	12.0	11.0
30	28.0	55.0	17.0	-
45	74.0	18.0	5.0	3.0
Mean	43.8	41.8	11.0	3.5
	DEEP TRENCH			
0	52.0	20.0	20.0	8.0
15	20.0	31.0	40.0	9.0
30	41.0	16.0	29.0	14.0
45	60.0	13.0	20.0	7.0
Mean	43.3	20.0	27.3	9.5

There were differences in coarseness of roots between check and trench treatments. Cotton roots from the check treatment were very fine and fibrous throughout their length compared with coarser roots from the trench treatments. Theoretically, coarse roots have anatomically better developed vessels than fine roots to enhance the conductance of water. This difference in coarseness may have been partly responsible for the earlier wilting plants in the check treatment.

Water intake rates of soils with dense or fine textured zones have been increased by various deep-tillage or profile modification methods (1, 4, 7). Improving water penetration and plant root development have been the primary benefits in soils without salt or shallow saline water table problems. However, in some soils, like Harlingen Clay, that have salt problems, an added benefit from trenching, along with increased water intake rates, has been the reduction of water soluble salts. Evidently, the increased water penetration caused leaching of the soluble salts from the plant root zone.

Table 2 shows salt data prior to initiation of the study and following two cotton seasons and one sugarcane season. If we observe the mean for all four depth increments from each treatment, a reduction of 30.6, 35.2, and 37.8% took place for check, shallow trench, and deep trench, respectively. The check treatment had the least salt reduction or change at 30- to 60- and 60- to 90-cm increments. Both trench treatments had a continuous reduction trend with depth at every sampling date.

The deep trench treatment proved the most efficient in salt reduction. When 1972 data are compared to 1970 for the whole 120-cm soil profile, a fourfold reduction in salinity occurred (1.87 and 7.58 mmhos/cm for check and deep trench, respectively). Leaching reduced salinity on all treatments, but trench treatments still maintained a lower salinity level than the check treatment at all depths. Some salt sensitive crops could probably be grown in Harlingen clay after salts have been moved down in the soil profile by leaching as enhanced by trenching.

In January 1973, the experimental area was planted to sugarcane and it received approximately 203 cm of water (127 by irrigation and 76 by rainfall) throughout the year. Theoretically, sugarcane requires about 152 cm of water to produce a normal crop, and 51 cm of water was used for leaching purposes. Fifty-one cm of water should have leached more salts from the soil profile than the data indicate. However, Harlingen clay has a very low infiltration rate, and it is also underlain by a high, saline water table, both of which increase surface runoff and reduce the effectiveness of the water for salt removal. During periods of high evaporation, soluble salts are pulled upward along with evaporating water. In addition, a high water requiring crop like sugarcane has an extensive root system. Salts move upward in the water as root extraction induces water flow from below the root zone.

Table 2. The average EC_e for 9- to 120-cm depth of soil profile at 30-cm increments prior to establishment of treatments and following 1971 and 1972 cotton seasons.

Depth from	Treatments and dates				Decrease from 2/70 to 10/73
	2/70	8/71	10/72	10/73	
cm	EC_e, mmhos/cm				%
			CHECK		
0 - 30	3.10	3.11	2.85	2.11	-31.9
30 - 60	5.10	4.51	5.24	3.61	-29.2
60 - 90	7.52	6.15	7.10	5.40	-28.2
90 - 120	9.29	8.23	7.95	6.20	-33.3
Mean reduction					-30.6
			SHALLOW TRENCH		
0-30	2.71	2.58	2.32	2.11	-22.1
30 - 60	4.66	3.84	3.53	2.96	-36.5
60 - 90	7.25	6.18	5.35	4.06	-44.0
90 - 120	9.06	7.75	6.65	5.60	-38.2
Mean reduction					-35.2
			DEEP TRENCH		
0 - 30	2.88	2.37	1.81	1.91	-36.0
30 - 60	5.08	4.28	3.18	2.80	-44.9
60 - 90	6.68	6.13	5.45	4.06	-39.2
90 - 120	9.66	7.00	6.28	5.98	-30.9
Mean reduction					-37.8

In some soils, profile inversion and mixing have raised subsoil high in clay content to the surface, and a reduction in water intake rate has occurred (7). However, this would not be a problem in Harlingen clay, since the texture of the profile is constant to a 180-cm depth. In some situations where the subsoil is deficient in nutrients, these could be incorporated in the backfill.

Even though this study was conducted using cotton, the results can be applied to horticultural crops grown on Harlingen clays of the Rio Grande Valley. Some vegetables typically grown on this same soil include onions, cabbage, carrots, turnip greens, and others.

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Chemical Control of Huisache in the Lower Rio Grande Valley of Texas

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ABSTRACT

Huisache, a serious pasture pest in the Lower Rio Grande Valley, can be effectively controlled by treating the shredded stumps with diesel fuel or the combination of the Tordon 225 herbicide and water. By basally applying these herbicides they can be used relatively safely in extensive agricultural areas with little drift hazard to surrounding agricultural crops.

Huisache [*Acacia farnesiana* (L.) Willd.] infestation is a serious brush problem on much of the pasture and native rangeland in south Texas. It infests over 2.5 million acres in Texas, predominantly in the southern portion of the state (5). Texas ranchers are concerned about the rapid encroachment of this woody species.

Both mechanical and chemical methods have been used to control huisache. Mechanical methods used are bulldozing, grubbing, and root plowing (4). Bovey, et al. (2) effectively controlled huisache by aerially applying picloram (4-amino-3, 5, 6, - trichloropicolinic acid) at the rate of 4 lb/acre in May and October. Hoffman and Ragsdale (3) killed individual huisache trees by treating the base of the trunk with 2, 4, 5, - T (2, 4, 5-trichlorophenoxy acetic acid) at 8 lb/100 gal of kerosene or diesel fuel. Bovey, et al. (1) found that mixtures of picloram and 2,4,5-T effectively controlled huisache in spring and fall applications.

Definition of Problem

Most land in the Lower Rio Grande Valley of Texas is used for producing citrus, vegetables, sugarcane, grain sorghum, and cotton; however, within these areas, many irrigated pastures are used for livestock or hay production. These are usually tracts of land not exceeding 15 or 20 acres. A major problem on these pastures is the invasion of woody species, particularly huisache. Huisache grows easily along drainage ditches and irrigation canal banks throughout the valley and quickly renders these areas impenetrable thickets. Because of the hazard of drift to surrounding vegetation, neither aerial application or ground broadcast spraying of herbicides can be used on these pastures. Thus, land owners usually resort to some means of mechanical control. Owners of such small acreages do not have the equipment to bulldoze or root plow, and often do not manage such areas intensively enough to justify custom brush control. Usually they shred these areas every 1 to 2 years, which often induces basal sprouting; the resulting tillers often produce a denser brush stand that the original one. Since many local ranchers and farmers have requested information on huisache control, we made this study.

Our objectives were to compare the effectiveness of various herbicides in water solution with that of herbicides in diesel fuel and diesel fuel alone, as a means of controlling huisache by the basal application method.

MATERIALS AND METHODS

This study was conducted 4 miles northeast of Weslaco, in Hidalgo County, Texas, on an 8-acre pasture, seeded to angleton bluestem grass (*Andropogon aristatus Poir.*) but invaded by huisache. Trees ranged from 3 to 8 ft tall, with trunk diameters of usually less than 3 inches. The soil type was a Hidalgo sand clay loam.

We used a completely randomized block design. Twenty-four 100 x 100 ft plots were marked off within the study area with a minimum of 25 trees per plot. The trees were shreded, and six different treatments were applied with four replications per treatment. The treatments used were diesel fuel, diesel fuel + Tordon 225 (picloram + 2,4,6-T), Tordon 225 + water, diesel fuel + Banvel (3,6 - dicloro-o-anisic acid), Banvel + water and a control. (Trade names are included for the benefit of the reader and do not imply an endorsement of or preference for the product listed by the U. S. Department of Agriculture.) The herbicides were mixed according to the manufacturer's recommendations. The Tordon 225 and Banvel (both 4 lb. acid equivalent/gal.) mixtures consisted of 16 oz herbicide/12.5 gal. of diesel fuel or water. Banvel 4-0. S. (oil soluble) was mixed with diesel fuel whereas Banvel 4-W. S. (water soluble) was mixed with water. All chemical mixtures were equivalent to 4 lb herbicide/100 gal of solution. About 1 pt of each specific treatment mixture was applied to the base of each huisache stump for each treatment, in December 1973, 1 to 2 days after trees had been shredded. The soil surface was dry and soil moisture in the upper 6 inches of the soil averaged 13% at the time of application. Since there was little wind at the time of application, drift hazards were minimal.

Plant mortalities were determined in January 1975, 13 months after application of treatment. Trees were counted dead if we could see no evidence of basal sprouts or live tissue.

RESULTS AND DISCUSSION

Percentage kill of huisache with diesel fuel, Tordon 225 + diesel fuel, Tordon 225 + water, and Banvel + diesel fuel did not differ significantly (Table 1). Diesel alone was as effective as combinations of diesel with Tordon 225 or Banvel. However, Tordon 225 + water gave as effective kill percentage as did diesel alone or combinations of diesel with either Tordon 225 or Banvel. The combination of Banvel and water did not effectively control huisache.

Table 1. Percent kill of huisache obtained by basal application of diesel, herbicide-diesel, and herbicide-water combinations at Weslaco, Texas. Average cost per individual tree is presented.

Herbicide treatment	Percent dead plants	Cost
	%	cents/tree
Diesel	97 a[1]	5
Tordon 225 + Diesel	95 a	7
Tordon 225 + Water	91 a	2
Banvel (O.S.[2]) + Diesel	90 a	7
Banvel (W.S.[3]) + Water	11 b	2
Control	0 c	-

[1] Numbers followed by the same letter do not differ significantly at the 1% level using Duncan's multiple range test.

[2] O. S. — Oil Soluble

[3] W. S. — Water Soluble

The effects of diesel alone and control (no herbicide treatment) on shredded huisache stumps at one year after application are shown in Figure 1. There was no evidence of live tissue on the plant treated with diesel; however, the plant from the control plot had grown new tillers that reached a height of 3 feet.

Diesel fuels or diesel fuels and herbicide combinations caused mortality of grass in the immediate stump area. Combinations of Tordon 225 or Banvel with water didn't have any injurious effects on grass.

These data indicated that either diesel fuel alone or combinations of Tordon 225 + water most effectively control huisache, using the basal application method. Diesel can be used with no hazard or drift to surrounding agricultural crops. Although drift hazards are small using the basal application method, Tordon 225 should be applied only when there is little or no wind. The average cost for killing huisache with Tordon 225 + water is 2¢/ tree, while diesel is 5¢/tree (Table 1).

ACKNOWLEDGEMENTS

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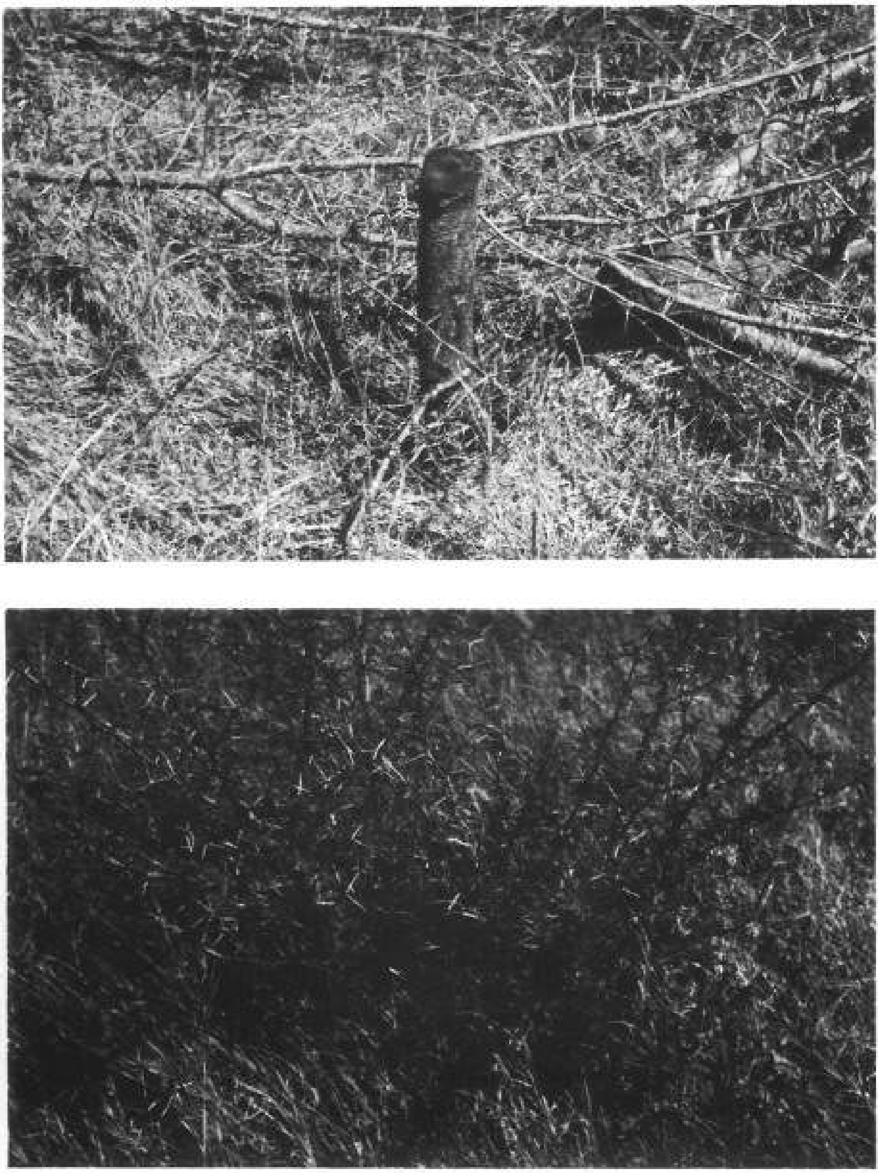

Fig. 1. Huisache stumps one year after applying diesel fuel (upper photo) and untreated control (lower photo).

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Direct Positive Process for Fast Production of Continuous Tone Black and White Transparencies

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ABSTRACT

A procedure is described for producing slides rapidly, economically, and conveniently.

Extension specialists, researchers, and administrators often need positive transparencies on short notice for slides to be used at meetings and working sessions, and other gatherings. When time is extremely short, they often use overhead transparencies which require an additional projector and interfere with the showing of 35 mm slides. In this note, a procedure is described for producing slides rapidly, economically, and conveniently.

PROCEDURE

This procedure produces black and white positive transparencies from Panchromatic film using Philip A. Hunt cine reversal chemicals (Philip A. Hunt, 47 to 50 30th Street, Long Island City, New York 11101). (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U.S. Department of Agriculture over others that may be commercially available.) Film exposure normally will be the same whether processed to a negative or positive. Film speed should be as recommended on the data sheet provided by the manufacturer with each roll of film.

The conventional procedure is to shoot the process film to a black and white negative (about 1 hr required), then contact or reshoot another film and process to a second generation negative (requiring an additional hr). The procedure suggested here produces the positive transparency in about 15 min using the reel process. Additional information and cautions in following the enumerated processing steps include:

Processing Solutions: Follow mixing directions carefully. The Philip A. Hunt reversal chemistry has been used very successfully and may be reused several times.

Processing: Reel.

Processing Temperature of all Solutions: 68 F.

Prewetting is mandatory for step one.

Agitation: Continuous for all solutions.

Step	Solution or procedure	Time required
1	Prewet	1 min
2	Cine developer	2 min
3	Wash	1 min
4	Cine bleach	1 min
5	Wash	1 min
6	Cine clearing bath	1 min
7	Wash	1 min
(Normal room light may be used during the remaining steps.)		
8	Re-expose	15 sec
(Use No. 2 photoflood lamps 2 ft from the film. Caution! Lamps get quite hot and will shatter if solution is allowed to get on the surface of the lamp.)		
9	Cine developer	1 min
10	Wash	1 min
11	Fixer	1 min
12	Wash	1 min
13	Photo-flo	30 sec
14	Dry	as required
	Mount slides in 2x2 frames	

By following these procedures carefully, a high quality, black and white slide with good contrast and halftones, and with good projection characteristics can be produced. This process has been successfully used since 1969 and some 2,000 rolls of film have been processed locally in this manner with very satisfactory results. For best results for charts and graphs, use a high contrast film.

Leaf Ultraviolet Radiation Reflectance, Transmittance, and Absorptance of Ten Crop Species

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ABSTRACT

Nitrogen oxide effluents from high-flying aircraft or chlorogluoromethane refrigerants and aerosol propellants that diffuse to the stratosphere might decrease levels of atmospheric ozone and increase the amount of middle-ultraviolet or UV-B radiation (28 to 315 nm) reaching the earth's surface with possible biologically damaging effects. We spectrophotometrically measured the leaf reflectance, transmittance, and absorptance of UV radiation over the 200- to 360-nm waveband for 10 crop species: blackeye pea, corn, cotton, grain, sorghum, pinto bean, redblush grapefruit, soybean, sugarcane, sunflower, and tomato. Leaves of the 10 crops reflected from 4 to 6% and absorbed from 94 to 95% of UV-B radiation; essentially none was transmitted. Therefore, outer plant canopy leaves might protect inner canopy leaves from damage by absorbing much of the nonreflected UV-B radiation. However, the transmission of UV-B damaged crop leaves needs to be determined.

Recently, concern has arisen over the possible supersonic aircraft-induced depletion of the stratosphere's ozone concentration by exhaust emissions of nitrogen oxides (3, 10) that might cause an increase in the amount of UV-B radiation (middle-ultraviolet, 280 to 315 nm) reaching the earth's surface (1, 5, 7, 8, 11). Also, chlorofluoromethanes, used as refrigerants and aerosol propellants, may diffuse to the stratosphere and destroy ozone (1).

Since a decrease in stratospheric ozone might markedly affect ground-level UV-B irradiance (4, 7), a model was developed (1) using epidermal transmission spectra (6) to describe the range of UV-B radiation regimes to be expected in plant communities with different stratospheric ozone concentrations.

Absorptance of UV-B radiation ranged from 90 to 96% for thick leaf epidermises and from 0 to 66% for thinner leaf epidermises of **noncrop** plants, except for onion (*Allium cepa* L.), that were used because their epidermises were easily removable (6). Therefore we speculated that leaves of plants with thick epidermises would have less damage to their inner mesophyll tissues by UV-B radiation than leaves with thinner epidermises, depending on possible UV-B radiation damage to epidermises themselves. Also, this work showed the need for spectral measurements on crop leaves with epidermises that are difficult to remove.

Our objective was to spectrophotometrically measure the leaf reflectance, transmittance, and absorptance of UV radiation over the 260- to 360-nm waveband for 10 crop species. This waveband includes the UV-B radiation that might be increased on the earth's surface by the partial destruction of the stratospheric ozone layer.

MATERIALS AND METHODS

One mature and healthy appearing leaf was collected from each of 10 randomly selected plants of 10 field-grown crop species: blackeye pea (*Vigna sinensis* Savi), redblush grapefruit (*Citrus paradisi* Macf.), corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), pinto bean (*Phaseolus vulgaris* L.), grain sorghum [*Sorghum bicolor* (L.) Moench.], soybean [*Glycine max* (L.) Merr.], sugarcane (*Saccharum officinarum* L.), sunflower (*Helianthus annuus* L.), and tomato (*Lycopersicon esculentum* Mill.). Leaves were wrapped immediately in Glad (plastic wrap), stored on ice to minimize dehydration, and transferred to the laboratory for measurements. (Mention of company or trademark is included for the readers' benefit and does not constitute endorsement of a particular product listed by the U.S. Department of Agriculture over others that may be commerically available.) Leaf collection and measurements for each crop species were conducted on different dates. In the laboratory, we measured leaf spectral reflectance, thickness, and green weight for all leaves of each species within 6 hr after their removal from the plant.

Total diffuse reflectance on the upper (adaxial) surface and transmittance of single leaves were measured with a Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment. Data were recorded at discrete 5-nm intervals over the continuously measured 200- to 360-nm waveband. Reflectance data (barium sulfate standard) were essentially absolute (2). Absorptance was calculated as: Percent absorptance = 100 - (% reflectance + % transmittance). Leaf thickness was measured using a linear-displacement transducer and digital voltmeter (9). Water content was determined on an over dry weight basis by drying at 68 C for 72 hr and cooling in a desiccator before final weighing.

Reflectance, transmittance, and absorptance data at each 20-nm increment over the 200- to 360-nm waveband were separately subjected to an analysis of variance (12). Duncan's multiple range test ($p = 0.01$) was used to test mean differences among the crops.

RESULTS AND DISCUSSION

Leaf Thickness and Water Content

Mean leaf thickness and leaf water contents of the 10 crops are given in Table 1. Leaf thickness ranged from 0.139 mm for grain sorghum to 0.298 mm for redblush grapefruit leaves. Water content has been shown to have little effect on the absorptance of UV radiation (5); our values ranged from 59.5% for redblush

Table 1. Leaf thickness and water contents, in ascending order of magnitude, of 10 crops.

Crop	Leaf thickness	Crop	Water content
	mm		%
Grain sorghum	0.139 a [1]	Redblush grapefruit	59.5 a [1]
Soybean	0.152 a	Grain sorghum	63.1 a
Corn	0.201 b	Corn	63.4 a
Sugarcane	0.211 bc	Sugarcane	69.2 b
Cotton	0.234 cd	Cotton	72.1 bc
Sunflower	0.242 d	Soybean	75.2 c
Blackeye pea	0.247 d	Pinto bean	82.4 d
Pinto bean	0.250 d	Sunflower	84.6 de
Tomato	0.288 e	Tomato	86.1 de
Redblush grapefruit	0.298 e	Blackeye pea	89.1 e

[1] Means followed by the same letter are not statistically significant ($p = 0.01$), according to Duncan's multiple range test.

grapefruit to 89.1% for blackeye pea. The coefficient for the linear correlation of leaf thickness with water content was not statistically significant.

Differences among species in leaf thickness and water content probably had little effect on their UV spectra because biochemical compounds in epidermises, such as flavonoids and related compounds, are responsible for must of the UV absorptance (5).

Spectral Measurements

The average leaf-reflectance transmittance, and absorptance spectra over all wavelength for the 10 crops are shown in Table 2. Although Duncan's multiple range tests indicated statistically significant differences among the crops; practically, the leaf spectral responses of all crops were essentially alike at all wavelengths. Average reflectance, transmittance, and absorptance of all wavelengths ranged from 4.2 to 5.8%, 0.24 to 0.32%, and 93.8 to 95.4%, respectively. The transmittance values were within the limits of instrument error.

These results for leaves are similar to a previous study with leaf epidermises of succulent plants (6), except for nonsucculent onion, where the average reflectance over all wavelengths measured for the 260- to 360-nm waveband ranged from 3.6 to 8.7%.

Table 2. Average reflectance, transmittance, and absorptance values over all wavelengths.

Crop Species	Reflectance	Crop Species	Transmittance	Crop Species	Absorptance
	%		%		%
Cotton	5.8 a[1]	Blackeye pea	0.32 a[1]	Blackeye pea	95.4 a[1]
Sugarcane	5.4 b	Sorghum	0.32 ab	Tomato	94.7 b
Sorghum	5.3 bc	Sugarcane	0.31 ab	Citrus	94.6 c
Soybean	5.3 bcd	Cotton	0.31 ab	Sunflower	94.6 cd
Corn	5.2 cd	Tomato	0.30 ab	Corn	94.5 cd
Pinto bean	5.2 cd	Citrus	0.29 bc	Pinto beans	94.5 d
Sunflower	5.2 de	Pinto bean	0.28 cd	Soybean	94.4 de
Citrus	5.1 e	Soybean	0.27 cd	Sorghum	94.4 ef
Tomato	5.0 f	Sunflower	0.27 d	Sugarcane	94.3 f
Blackeye pea	4.2 g	Corn	0.24 e	Cotton	93.8 g

[1] Means followed by the same letter are not statistically significant ($p = 0.01$) according to Duncan's multiple range test.

Coefficients for the linear correlations of reflectance, transmittance, and absorptance with leaf thickness and with water content at the 280-nm wavelength in the critical UV-B radiation band were not statistically significant.

CONCLUSION

Leaves of 10 crops all reflected from 4 to 6% and absorbed from 94 to 95% of spectrophotometrically measured UV-B radiation; none was transmitted. Since both monocotyledonous and dicotyledonous plants were used in this study, it is highly probable that similar spectral results would be obtained for leaves of other crop plants. Therefore, outer plant canopy leaves might protect inner canopy leaves from damage in these species studied by absorbing much of the nonreflected UV-B radiation. However, the transmissivity of UV-B damaged crop leaves needs to be determined.

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