JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 29, 1975

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Published by

RIO GRANDE VALLEY HORTICULTURAL SOCIETY
P. O. Box 107, Weslaco, Texas 78596

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Aims and Objectives of the Society

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

At regular meetings, September-April, subjects of interest are presented by specialists in their field. These presentations are followed by open forums. The Newsletter announces and discusses the monthly programs and brings other news of interest to Society members. The Society has sponsored 29 annual Insitutes, where outstanding speakers from all parts of the country present new developments in the field of horticulture. Panel discussions, social get-togethers and a barbeque round up the all-day program.

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

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

Dr. Roger Albach
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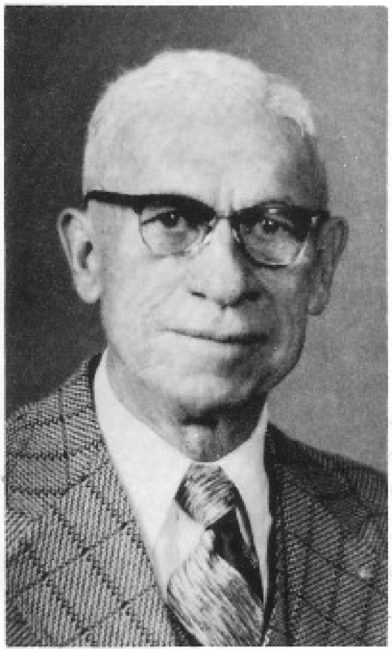

Dr. J. B. Corns received his B.S. degree from Texas A. & M. University; his M.S. from the University of California; and his Ph.D. from Cornell University. His training has been in the agricultural field with specialization in horticulture. He served as a research assistant at Cornell University, on the extension staff of the University of Illinois, and has served on the faculty of Texas A & I University. He has been on the faculty of Pan American University since 1948 where he specialized in horticulture, but has taught classes in various phases of agriculture. For the last 15 years he has taught a course, "Conservation of Natural Resources" to a very large number of students, hundreds of them who are now teaching here in South Texas.

Dr. Corns has traveled extensively in South and Central America and Mexico studying and instructing in the fields of agriculture. Corns has also co-authored a book, "Production of Field Crops," by J. S. Mogford and J. B. Corns. This book was used by many colleges in Texas as an agronomy textbook.

In 1973, Dr. Corns was nominated for "Piper Professor of 1973" by the president and faculty of Pan American University. The Minnie Piper Awards are made for outstanding academic, scientific, and scholarly achievement.

During World War II, Dr. Corns served as officer in charge of Quartermaster marketing centers in New Orleans, Alexandria, La., and Baltimore, Maryland. Corns is now a retired Lt. Colonel.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY
PATRON AND SUSTAINING MEMBERSHIP, 1975

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January 21, 1975

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USDA, ARS, Weslaco

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Agricultural Research and Education
Center, Lake Alfred, Florida

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Area Specialist, Texas
Agricultural Extension Service,
Weslaco

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Plant Pathologist, Texas
Agricultural Extension Service
Weslaco

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Harlingen

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TALKS PRESENTED AT THE 29th ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY

What the Citrus Fresh Fruit Industry Must Do to Stay Competitive

W. Grierson
Prof. of Horticulture
Agr. Res. and Educ. Center
Univ. of Florida, IFAS
Lake Alfred, Fl 33850

To remain truly profitable, the fresh citrus industry needs to hew closely to two precepts, neither of which have had much adherence in the past. The first precept is that the only figure in accounting that truly matters is *net return per acre*. High early fruit prices at the packinghouse do not mean a thing unless they result in a realistic net return per acre. The first secret to profitability is high pack-out and that involves ever-increasing coordination between production and packinghouse management. The second precept is that all else is incidental, perhaps expendable, that comes between the two essential hands; the hand that takes the fruit off the tree and the hand that picks it up off the retail counter. If either of these hands fails, we are out of business. No matter what it takes, pickers must be retained that will harvest fruit with reasonable care, and the housewife must be presented with an attractive piece of fruit with a reasonable shelf life. Moreover, we must beware of becoming too dependent on fungicides to correct the effects of rough handling in the field and adverse conditions thereafter. What the EPA gives (reluctantly) the EPA can take away (probably joyously). Every effort must be made to develop handling conditions that are helpful to the fruit, which may, at any time, have to do without any chemical aid on which we now rely. The first, best, and most EPA-proof measure is use of high humidity (*not* wet), particularly before the fruit is waxed.

Control of Plant Diseases around the Home

Jose M. Amador
Area Plant Pathologist
Texas Agr. Ext. Serv.
Weslaco, TX 78596

The following ideas are suggested as means of avoiding diseases from becoming established in the home garden:

1. Site selection. Choose a well-drained area.
2. Soil preparation. Encourage maximum growth.
3. Variety selection. Plant disease-resistant varieties.
4. Disease-free transplants. Prevent spread of disease into garden.
5. Proper type and rate of fertilizer. Encourage maximum growth.
6. Plant when soil temperature is correct. Reduce losses to seedling disease.
7. Watering. Reduce foliage diseases.
8. Mulches. Prevent fruit rots and encourage maximum growth.
9. Weed control. Reduce alternate host for vegetable disease.
10. Row spacing. Improve air circulation and reduce foliage disease.
11. Alternate planting. Prevent buildup of disease.
12. Rotation. Avoid soil disease buildup.
13. Insect control. Prevent virus spread.
14. Proper harvesting. Avoid storage decay.
15. Sanitation. Prevent buildup of diseased plant tissue in garden.
16. Fungicide application. Control diseases should they become established.

All pesticides should be used with appropriate precautions. The best source of information concerning the proper use of a given fungicide is the label printed on every container. Care must be taken to become familiar with precautions and recommendations for the proper use of chemicals in the home garden. BEFORE USING ANY PRODUCT, BE SURE TO READ THE LABEL.

Proper storage is also important. There should be a place designed for pesticides. Such a place should be away from the reach of children, uninformed persons and pets.

Pesticides are safe when used properly. The following list suggests some common fungicides that are very safe when used according to directions.

FUNGICIDES SUGGESTED FOR HOME GROWN VEGETABLES

Vegetable	Fungicide	Oz/5 Gallon of Water
Beans		
Bacterial Blight	Kocide 101	3
White Mold	Benlate	2.5
Downy Mildew	Maneb	5
Powdery Mildew	Wettable Sulfur	15
Rust	Maneb	5
Cabbage, Cauliflower, Broccoli, Brussel Sprout		
Downy Mildew	Maneb	5
Alternaria Spot	Maneb	5
Carrot		
Leaf Blight	Maneb	5
Cucumber, Cantaloupe, Watermelon		
Powdery Mildew	Benlate	1
Alternaria Spot	Maneb	5
Downy Mildew	Maneb	5
Angular Leaf Spot	Kocide 101*	3
Lettuce		
Drop	Maneb	5
Downy Mildew	Maneb	5
Onions		
Tip Blight	Maneb	5
Purple Blotch	Maneb	5
Pepper		
Bacterial Spot	Kocide 101	3
Pumpkins and Squashes		
Powdery Mildew	Benlate**	1
Downy Mildew	Maneb	5
Spinach		
Downy Mildew	Maneb	5
White Rust	Maneb	5
Tomatoes		
Leaf Blight	Maneb	5
Leaf Mold	Maneb	5
Bacterial Spot	Kocide 101	3

Turnip, Radishes		
Downy Mildew	Maneb	5
Anthracnose	Maneb	5

*Kocide 101 is not cleared on watermelons.
**Benlate is not cleared on pumpkins.

These chemicals are current insofar as present information available. However, registrations and instructions change periodically so be sure to read the label before using any chemical.

"The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Texas Agricultural Extension Service is implied."

RESEARCH REPORTS

RESEARCH REPORTS

Effect of Drip and Flood Irrigation on Mineral Nutrition of Young Grapefruit Trees

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Monte Alto, Texas 78538

ABSTRACT

Leaf concentrations of N, P, Na, Fe, Zn, and Cu were higher, and those of Ca and B lower, in drip-irrigated young grapefruit trees on 20 rootstocks as compared to flood-irrigated trees. Irrigation method had no effect on the uptake of K, Mg, Mn, and Cl^-. Rootstocks influenced the leaf levels of all 12 elements, but there were few differences induced by different selections of the same rootstock variety.

Drip irrigation has recently come into wide use in the warmer regions of the United States. Plugging of the emitters caused problems in some areas of Florida (2, 3), but drip-irrigated acreage is still expanding, especially in the western United States. In attempts to determine the effect of drip irrigation on Cl^- and B uptake, we found that young grapefruit trees on 15 rootstocks sometimes showed differences in the leaf levels of these elements with drip irrigation as compared to flood irrigation (7). Mature avocado trees accumulated more Cl^- and Mn after they were put under drip irrigation (9). The present experiment was carried out to compare the uptake of 12 elements under drip and flood irrigation, to determine the effects of rootstocks on the absorption of these elements, and to investigate differences in nutrient uptake between different selections of the same variety.

MATERIALS AND METHODS

Seed of 18 selections of 10 citrus cultivars was obtained from the Florida Budwood Registration Program and the U.S. Horticultural Research Laboratory in Orlando, Florida. Seed of two cultivars from Texas was also used (Table 1). The seedlings were grown in pots and grafted with nucellar Ruby Red grapefruit, *Citrus paradisi* Macfd., in December 1972/January 1973. In May 1973, replications of each rootstock-scion combination were planted (30-cm spacing) in 10 plots surrounded by soil borders in randomized complete blocks. Five of these plots, randomly distributed, were flood-irrigated with river water every 2 weeks during dry periods, or as needed during rainy periods. To the other five plots, river water was applied by drip irrigation from 1.27 cm diameter polyethylene plastic pipe with short lengths of 1.1 mm diameter tubing as emitters. There was one emitter for every two plants, delivering about 2 liters of water/hr for 6

Table 1. Rootstocks

Citrus reticulata Blanco
Cleopatra (Texas)
C. celebica Koord. hybrid
Alemow (Texas)
Alemow H-181
C. limon (L.) Burm. f. and hybrids
Rough lemon S-SPB-51-2
Rough lemon S-514-29-12
Rough lemon S-514-29-13
Rough lemon Variant DPI 407
Heyman's red rough lemon FF 9-1-61
Lemon hybrid (golden, di giorgio)
Iran lemon HF 2-9-9
Ponderosa lemon Snell
C. reticulata var. austera Swing. hybrid
Rangpur lime SF/19-22
Rangpur lime H-44
Poncirus trifoliata (L.) Raf. x *C. sinensis* (L.) Osbeck
Carrizo citrange SPB 330
Carrizo citrange S-F/52-14
Carrizo citrange S-F/52-16
Troyer citrange S-F/52-1
Troyer citrange S-F/52-2
Rusk citrange HF-7-16-15
P. trifoliata x *C. paradisi* Macf.
Citrumelo W-2

hr/day, except during rainy weather when the system was shut off. The trees were fertilized with ammonium nitrate, broadcast by hand, in April and August. The soil was Willacy fine sandy loam, pH 7.8 to 8.0, with an electrical conductivity (EC) of the saturation extract of 0.55 to 0.84 millimhos/cm at the beginning of the experiment. The irrigation water contained 4.1 to 4.3 meq/liter Cl^-, 6.4 to 6.6 meq/liter of Na, and 4.6 to 5.4 meq/liter $SO_4^{=}$. The sodium adsorption ratio was 5.3; the EC varied from 1.04 to 1.16 millimhos/cm. Samples of mature leaves from each tree were collected at the beginning of November 1973. The leaves were analyzed for N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, Na, Cl^-, and B by methods previously described (6).

RESULTS

The overall means for irrigation treatment (Table 2) show that the N, P, Na, Fe, Zn, and Cu levels in the leaves were higher with drip irrigation than with flood irrigation; the opposite was true for Ca and B. Irrigation method had no effect on the uptake of K, Mg, Mn, and Cl^-. Some rootstocks reacted consistently contrary to the general trend, and as a result, there were significant rootstock x irrigation method interactions (Table 3). This was particularly true for Iran lemon HF 2-9-9 and Rusk citrange HF 7-16-15. These rootstocks induced higher levels of P, Zn, and Cu with flood irrigation. P, Zn, and Cu were the only elements where rootstock x irrigation methods interactions were found. Other rootstocks reacting opposite to the general trend were Carrizo SPB 330 (An), and Rough lemon Variant DPI 407, Troyer S-F/52-2, and Alemow H-181 (Cu).

Leaf concentration of all 12 elements was affected by rootstock (Table 4). The range of levels found was normal for the area; the Cl^- levels were lower than those found in a similar, earlier experiment (7) because of heavy rains in the fall of 1973. Relatively high N levels (>2.30%) were found with Alemow (Texas), Alemow H-181, and Citrumelo W-2. Trees on Rough lemon S-SPB-51-2, Carrizo SPB 330, Rusk citrange HF-7-16-15, and Rough lemon Variant DPI 407 had relatively low (<2.15%) N levels. P concentration in the leaves was high (>0.229%) with Troyer S-F/52-2, Citrumelo W-2, Carrizo S-F/52-14, Carrizo S-F/52-16, and Troyer S-F/52-1; P was low (<0.150%) with Rough lemon Variant DPI 407, Lemon hybrid, and Rangpur SF/19-22. Ponderosa lemon Snell and Lemon hybrid were most efficient in taking up K (>2.38%), while Cleopatra (Texas) induced the lowest (1.47%) K level. Ca was relatively high (>2.60%) with Cleopatra (Texas), Rough lemon Variant DPI 407, and Rough lemon S-SPB-51-2. Low Ca levels (<2.10%) were induced by Ponderosa lemon Snell and Rusk citrange HF-7-16-15 rootstocks. Cleopatra (Texas) and Troyer S-F/52-1 took up the most Mg (>0.30%), and Alemow (Texas), Alemow H-181, and Ponderosa lemon Snell (<0.22%) took up the least Mg. Iran lemon had the strongest tendency to absorb Na (0.29%); Na levels were low (<0.17%) with Lemon hybrid and Rough lemon S-514-29-12. The relatively high Fe levels (>80 ppm) with Citrumelo W-2, Iran lemon HF 2-9-9, and Alemow (Texas) were in contrast with low Fe levels (<57 ppm) on Heyman's Red rough lemon FF 9-1-61, Rough lemon S-514-29-12, and Rough lemon Variant DPI 407. Mn was high (>30 ppm) with Rough lemons S-SPB-51-2 and S-514-29-13, and low (<16 ppm) with Carrizo SPB 330. Zn ranged from 22.8 ppm with Iran lemon HF 2-9-9 rootstock to 11.9 ppm with Cleopatra (Texas) rootstock. Trees on Rusk citrange HF-7-16-15 took up the most Cu, and those on Alemow (Texas), Rangpur SF/19-22, and Cleopatra (Texas) took up the least. Cl^- accumulation varied widely. High levels (>5,000 ppm) were found with Carrizo S-F/52-14 and SPB 330, Troyer SF/52-1 and SF/52-2; low levels (<1,600 ppm) with Cleopatra (Texas), Rangpur lime H-44 and SF/19-22, and Lemon hybrid. There was less variation in B uptake. Ponderosa lemon Snell and Cleopatra (Texas)

Table 2. Means of concentrations of 12 elements in leaves (dry wt) of young grapefruit trees on 20 rootstocks with drip and flood irrigation.

Element	Drip	Flood	Statistical significance
(%)			
N	2.31	2.16	*
P	0.215	0.171	*
K	1.92	2.02	N.S.
Ca	2.28	2.42	*
Mg	0.27	0.27	N.S.
Na	0.22	0.16	*
(ppm)			
Fe	75.4	59.4	*
Mn	25.1	24.8	N.S.
Zn	21.1	14.4	*
Cu	8.0	7.1	*
Cl^-	3,076.1	3,257.9	N.S.
B	168.2	179.9	*

* Difference significant at the 5% level.

accumulated (>200 ppm) B, Alemow H-181, Troyer S-F-52-2, and Carrizo SPB 330 kept leaf B low (<154 ppm).

In general, selections from varieties were similar in their nutrient uptake patterns. There were no significant differences between the selections of Alemow and Rangpur. Among the five selections of rough lemon, S-514-29-13 induced the highest levels of leaf N and S-SPB-51-2 induced the lowest. With Rough lemon Variant DPI 407 and S-514-29-13 rootstocks, the leaf Mg levels were higher than with S-514-29-12 and Heyman's Red rough lemon FF 9-1-61. Rough lemon S-SPB-51-2 accumulated more Mn than S-514-29-12, and S-514-29-13 more than Heyman's Red rough lemon FF 9-1-61. Carrizo S-F/52-14 rootstock increased leaf N levels over SPB 330 and Cl^- levels over S-F/52-16. Trees on Troyer S-F/52-2 rootstock had a higher P concentration in the leaves than trees on S-F/52-1.

Table 3. Significant (P = 0.05) interactions of irrigation method x individual rootstock.

Rootstock	Drip	Flood
	P (%)	
Carrizo SPB 330	0.208	0.212
Iran lemon HF 2-9-9	0.148	0.232
Rusk citrange HF-7-16-15	0.183	0.255
	ZN (ppm)	
Iran lemon HF 2-9-9	19.8	25.8
Rusk citrange HF-7-16-15	18.0	18.2
	Cu (ppm)	
Rough lemon variant DBI 407	7.8	8.4
Iran lemon HF 2-9-9	7.0	8.6
Troyer S-F/52-2	8.0	9.0
Alemow H-181	7.0	8.0
Rusk citrange HF-7-16-15	8.8	13.4

Table 4. Rootstock effects on concentration of 12 elements in the leaves.

Rootstock	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Cl (ppm)	B (ppm)
Cleopatra (Tex.)	2.17bcd[z,y]	0.171defgh	1.47d	2.77a	0.35a	0.19b	57.0cd	27.5abcd	11.9d	6.2cd	1,453.2f	207.4ab
Alemow (Tex.)	2.55a	0.162fgh	1.93abcd	2.33bcdef	0.21g	0.18b	83.8ab	26.7bcd	13.7cd	5.4d	2,576.8d	157.8de
Alemow H-181	2.41ab	0.178cdefgh	2.19abc	2.31bcdef	0.21g	0.17b	73.3abcd	26.9bcd	14.7bcd	7.5bcd	2,037.2def	151.9e
RL S-SPB-51-2	2.03d	0.170efgh	2.13abc	2.66ab	0.27cd	0.18b	57.3cd	34.3a	21.4a	7.7bcd	2,100.6def	173.6cde
RL S-514-29-12	2.27bcd	0.186bcdefgh	2.18abc	2.49abcd	0.26de	0.16b	55.6cd	26.3bcde	19.8abc	7.4bcd	2,290.9def	178.7bcde
RL S-514-29-13	2.30abc	0.171defgh	1.76bcd	2.54abc	0.29bc	0.18b	64.6abcd	33.3ab	18.7abc	7.3bcd	2,634.9d	172.5cde
RL Variant DPI 407	2.11cd	0.142h	2.19abc	2.67ab	0.29bc	0.20b	56.2cd	29.2abc	20.0abc	8.1bc	2,123.4def	181.4bcde
Heyman's RL FF	2.23bcd	0.176cdefgh	1.70cd	2.54abc	0.26de	0.17b	54.0d	24.5cdef	18.4abcd	7.1bcd	2,536.0d	183.3abcd
Lemon Hybrid	2.16bcd	0.149gh	2.39ab	2.38bcde	0.22fg	0.16b	63.0abcd	25.4cdef	20.6ab	7.1bcd	1,577.4ef	172.2cde
Iran Lemon HF 2-9-9	2.16bcd	0.190bcdfgh	1.83bcd	2.29cdef	0.24ef	0.29a	85.9a	29.5abc	22.8a	7.8bcd	2,806.8cd	196.8abc
Ponderosa (Snell)	2.26bcd	0.182bcdfgh	2.50a	2.01f	0.21fg	0.17b	67.2abcd	18.8fg	19.2abc	8.0bcd	3,084.0cd	213.6a
Rangpur 19-22	2.27bcd	0.149gh	2.15abc	2.12ef	0.23fg	0.20b	64.9abcd	24.7cdef	21.6a	6.0cd	1,557.5f	156.6de
Rangpur H-44	2.29abcd	0.157gh	1.99abcd	2.28cdef	0.24ef	0.22b	60.3bcd	27.5abcd	17.9abcd	7.2cd	1,500.3f	174.5cde
Carrizo SPB 330	2.05d	0.210bcdfg	2.05abcd	2.31bcdef	0.30b	0.19b	66.8abcd	15.2g	12.0d	7.2bcd	5,296.4ab	153.1de
Carrizo S-F 52-14	2.30abc	0.236bc	1.76bcd	2.36cdef	0.30b	0.18b	67.1abcd	19.3efg	16.5abcd	7.4bcd	6,056.8a	166.5cde
Carrizo S-F 52-16	2.19bcd	0.232bcd	1.90abcd	2.26cdef	0.30b	0.21b	71.9abcd	19.2efg	13.7cd	7.3bcd	4,775.6b	167.5cde
Troyer S-F 52-1	2.26bcd	0.230bcde	1.71cd	2.31bcdef	0.32b	0.22b	69.9abcd	22.8cdef	17.9abcd	9.0ab	5,149.6ab	160.7de
Troyer S-F 52-2	2.29abcd	0.314a	1.75bcd	2.16ef	0.30b	0.21b	64.0abcd	20.6defg	17.8abcd	8.5bc	5,137.0ab	152.0e
RUSK HF-7-16-15	2.10cd	0.219bcdef	2.03abcd	2.02ef	0.30b	0.19b	78.8abcd	25.8cdef	18.1abcd	11.1a	4,696.2b	178.7bcde
Citrumelo W-2	2.33ab	0.242b	1.85bcd	2.24cdef	0.27cd	0.17b	86.8a	21.5defg	18.4abcd	7.9bcd	3,729.6c	181.4bcde
HST	0.27	0.062	0.65	0.37	0.03	0.07	23.6	7.2	6.7	2.6	934.9	31.1

[z]Means of analysis each based on one sample collected from one tree.

[y]Means not followed by the same letter differ significantly at the 95% level according to Tukey's test.

DISCUSSION

We used very young trees in the experiment because they lack reserves, and differences in nutrient absorption are more readily detected in their leaves. Drip irrigation sharply reduces fluctuation in moisture content in the root sphere. The resulting changes in root activity and nutrient availability are reflected in the differences in leaf concentration between drip-irrigated and flood-irrigated plants (Table 2). The rootstocks in the tests were genetically heterogeneous. That some of them reacted differently from the rest (Table 3) to the conditions resulting from two types of irrigation is therefore not surprising. Several factors could explain why N, P, Fe, Zn, Cu, and Na were taken up in greater amounts with drip irrigation than with flood irrigation, and Ca and B in smaller amounts. Soil moisture and the size and type of root system were probably implicated. Greater availability of Fe and reduced absorption of Ca with high soil moisture levels often have been observed (4). Antagonisms between elements are also a factor (4).

Many of the rootstock effects on mineral element uptake shown in Table 4 agree with earlier reports (1, 8). The effects of such little used rootstocks as Ponderosa lemon and of new hybrids and selections are of interest. The selections from established rootstock varieties like Rough lemon and Carrizo, although they vary in other horticultural and morphological characteristics, differed little in their effects on nutrient uptake (Table 4). As earlier work has shown (5, 8), marked differences in nutrient uptake are usually linked with pronounced genetic difference.

ACKNOWLEDGMENTS

We are grateful to Dr. Don Hutchison, U. S. Horticultural Research Laboratory, Orlando, Florida, for supplying us with seed and to H. Del Var Peterson, USDA, ARS, College Station, Texas 77840, for statistical analysis of the data.

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Comparison of Three Irrigation Systems for Young Citrus Trees

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ABSTRACT

Strip watering, ring watering and drip irrigation were compared in a newly planted grapefruit orchard on Hidalgo clay loam soil. During the first two years after planting there were no significant differences in tree growth as measured by increase in trunk diameter. Water use efficiency was greatest under drip irrigation with ring watering second, while strip watering was comparatively inefficient.

During a period of low rainfall some salt accumulated at the wet soil surface and along the wetted front beneath the surface under drip irrigation. The salt build-up was leached out of the root zone following a period of high rainfall.

Based on historical record irrigation water in the Lower Rio Grande Valley is deficient 3 years out of 10 (5). Growers need to be aware of techniques which can increase water use efficiency (yield or growth per unit of water). Strip watering and ring watering are regularly used on young citrus orchards to stretch a limited water supply.

Balled and burlapped citrus trees have the root system confined to a cylinder of soil about 10 inches in diameter and 10-12 inches long. With 100-150 trees an acre the efficiency of applying irrigation water to an entire acre to water 150 limited root systems is apparent.

In strip watering borders of soil about 12 inches high are put up on either side of the tree. A strip approximately 6 ft wide down the tree row is then irrigated. Since only about one fourth of the total acreage is irrigated a substantial water saving results.

For ring watering a ring of soil about 5 ft in diameter is formed around the tree and 25-50 gal of water is applied from a tank wagon. Since only the area immediately adjacent to the root system is wetted a further saving in water is possible even over strip watering.

Since about 1970 some reports have appeared in the literature concerning drip irrigation (2). Water savings, increases in yield, and the successful use of highly saline water have all been credited to this method of irrigation (1, 3, 4).

Strip irrigation obviously requires less water than flooding, and both ring watering and drip irrigation obviously require less water than strip irrigation. The question remains whether or not satisfactory tree growth can be obtained under these water-saving systems. This study compares drip irrigation with conventional systems of starting newly planted citrus orchards with respect to water use efficiency and salinity hazard.

MATERIALS AND METHODS

Star Ruby grapefruit on sour orange rootstock were planted on Hidalgo clay loam soil in March 1971. Irrigation treatments were arranged systematically with ten trees to a row and two rows of each treatment. Rings of soil were formed around trees to be ring watered. Borders were erected on either side of trees to be strip watered. Drip irrigation was supplied through microtubing adjusted to deliver 1 gal/hr.

Soil moisture changes were followed with a neutron probe. On the basis of previous experience strip irrigation and ring watering were scheduled when soil moisture, as estimated in an access tube 3 ft from the trunk, was reduced to 30% available at the 1-ft level. For drip irrigation the neutron method of estimating soil moisture was not satisfactory because differences in the amount and nature of soil cracking, and in the size and distribution of clods in the vicinity of the young tree affected the size and shape of the wetted volume of soil around the tree. Drip irrigation was scheduled on the basis of pan evaporation.

Tree growth was estimated by trunk diameter measurements 6 inches above the budunion made at time of planting and one and two years later. In August 1971, after 6 months of differential irrigation treatments and only 8 inches of rain, soil samples were taken 1, 3, 6, and 12 ft from tree trunks in each of the irrigation treatments. Samples were taken through 6 ft in 1-ft increments. Electrical conductivity measurements were made on a saturation extract to estimate salt build-up. In late April 1972, following a period of 6 weeks without rain soil samples were taken again. The next sampling was made in August 1972 following a 4-month period with nearly 20 inches of rain.

RESULTS AND DISCUSSION

The average trunk diameters of the 20 trees in each treatment is listed for the three measurement dates (Table 1). There were no significant differences in trunk diameter at time of planting (March 1971). There were still no significant differences attributable to irrigation treatment after one and two years of growth. The magnitude of the increases in trunk diameters indicate that the trees grew at an acceptable rate during the period of study.

Table 1. Growth of young Star Ruby grapefruit trees under several irrigation systems.

Irrigation system	Trunk diameter, inches		
	3/71	3/72	3/73
Strip water	0.98	1.18	2.09
Ring water	0.91	1.30	2.36
Drip	1.02	1.26	2.28
	NS	NS	NS

The amount of irrigation water supplied to each treatment and the rainfall during the period of study are presented in Table 2. In both years drip irrigation used the least water, followed closely by ring watering, while strip watering used the most. From March 1971 to March 1972, a period of normal rainfall, strip required seven times more water than drip irrigation. From March 1972 to March 1973, a period of high rainfall, strip required four times as much. Since the trees grew equally well under all irrigation systems water use efficiency is much greater for drip or ring watering than for strip. Water saving by drip irrigation depends on the inefficiency of the method replaced (1).

Table 2. Amount of irrigation water supplied to young Star Ruby grapefruit trees under different irrigation systems and rainfall received March 1971 to March 1973.

Irrigation system	Irrigation water/tree (gal)	
	3/71 to 3/72	3/72 to 3/73
Strip water	4100	2618
Ring Water	700	975
Drip irrigation	580	602
Rainfall, inches	25.5	41.1

During the first year strip watered trees were irrigated ten times. From 2-5 inches of rain fell within 24 hr after several of the irrigations. Such unfortunate timing of irrigation is a problem growers regularly encounter with our unpredictable rainfall pattern.

Under drip irrigation where a limited volume of soil is kept at a relatively high moisture content the hazard of salinity has to be considered. The greatest concentration of salt is likely at the wet surface where evaporation is continually taking place. High salt concentration is also likely beneath the surface at the edge of the wetted front where moist soil meets dry soil. In August 1971 electrical conductivity measurements on a saturation extract revealed no salt build-up under any of the treatments. Conductivity values were all less than 2 millimhos.

Salinity profiles for the three irrigation treatments are presented (Table 3). Values for strip and ring watering indicate normal salt concentrations. Under drip a considerable salt build-up was found in the 0-1 inch level close to the trunk. Below 2 inches EC values were normal within the wetted area.

Table 3. Salinity profile under three irrigation systems in a young Star Ruby grapefruit orchard, April 1972.

Irrigation treatment:	Strip	Ring	Drip	
Distance from trunk, inches:	24	24	6	24
Soil depth, inches				
0-1	2.5[a]	2.6	26.5	5.0
1-2	1.2	1.2	3.8	1.7
2-6	1.1	1.0	2.1	1.5
6-12	1.0	1.0	1.9	0.8
12-24	0.8	0.9	1.5	0.6
24-36	0.7	1.0	1.5	0.6

[a] Electrical conductivity, mmhos

A trench was made on one side of a drip irrigation tree to determine the extent of the wetted soil zone and to check salinity at the wetted front. On the surface the wet soil formed an irregular, somewhat circular, zone having a diameter of 2 to 3 ft. Beneath the surface the wetted volume was 4-5 ft wide and about 18 inches deep. The greatest lateral movement was a depth of 6-10 inches. An abrupt change in soil texture from clay loam to sandy loam occurred at about the 18-inch level. The sandy loam had a lower moisture content than the clay loam above. Drip irrigation water moved laterally in the clay loam and not down into the sandy loam. Soil samples taken along the wetted front gave an EC of 5 mmhos indicating a slight build-up of salt.

The next soil sampling was made in August 1972 following a 4-month period with nearly 20 inches of rain. All EC values to a depth of 3 ft were less than 2 mmhos. Any salt accumulation under drip irrigation had been leached beyond the root zone. While this was a period of high rainfall the results suggest that any build-up of salt occurring under drip irrigation would be leached out by the average annual rainfall of about 25 inches.

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Drip Irrigation on Bearing Citrus Trees

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ABSTRACT

Drip irrigation at three rates was used on bearing red grapefruit for 3 years. There were no significant differences in total yield or in fruit size distribution attributable to the amount of irrigation water applied. On medium textured soil with 100 trees/acre a water saving of 20% was possible using drip irrigation instead of flood irrigation.

Early claims of water savings of 80-90% under drip irrigation were generally not based on controlled experiments. However, data from more rigorous work has shown that drip irrigation can provide high water use efficiency (2). The water saving in a particular situation depends on the efficiency of the system with which drip is being compared (1). The more efficient the original system the smaller the possible saving. In the case of young citrus trees where the root system occupies a limited soil volume water use efficiency is greater under drip than under flood or strip watering (4).

Bearing citrus orchards are different. As the trees grow the roots explore a greater volume of soil and the tree canopy continually covers more of the soil surface. With current tree populations of 100 to 150 trees/acre canopies are sufficiently large by about the eighth year that hedging may be necessary to provide access for equipment. In orchards on level land, with water delivered by underground pipeline, and with irrigation runs of proper length water use efficiency with flood irrigation can be high.

At the Citrus Center the number of flood irrigations applied annually has varied from three to eight with an average of five over the past 20 years. Rainfall during this period ranged from 8 to 39 inches. Metering has shown a typical irrigation to be 6 acre-inches. With an average of five irrigations a year this equals 30 acre-inches or: with 100 trees/acre 8,146 gal/tree; with 150 trees/acre 5,413 gal/tree. The amount of water to apply to citrus under drip irrigation in the Lower Rio Grande Valley has not been precisely determined. This study examines the effect of several amounts of drip irrigation water on yield and size of red grapefruit.

MATERIALS AND METHODS

In the spring of 1972 a drip irrigation experiment was initiated in a block of 12-year-old red grapefruit on sour orange rootstock. There were three rates of water application with nine replications in a randomized complete block design. The soil was Hidalgo clay loam underlain by sandy loam at about 3 ft.

Drip water requirements have been estimated by a formula in which pan evaporation data is related to the area covered by the plant canopy and modified by a water use factor of 0.7 (3). Long-term Class A pan evaporation data for the Lower Rio Grande Valley (5) were used in this manner to arrive at a basic rate of application (Table 1).

The three rates in the study are referred to as low, medium, and high. In 1972 and 1973 the amount calculated from the pan evaporation formula for a 15 ft diameter tree (6900 gal/year) was set as the medium rate. The low rate was one-third less; the high rate one-third more. In 1974 the calculated rate was set as the low rate with the medium rate 50% more and the high rate 100% more. The amounts actually applied and the annual rainfall are listed (Table 2). In 1971, prior to converting to drip, this orchard received six flood irrigations and 24.5 inches of rain.

Fruit was harvested, weighed, and sized on an individual tree basis in January of each year. In 1974 ten fruit were tagged on each of three trees in each treatment and diameters measured every two weeks from May to December.

RESULTS AND DISCUSSION

Total yields (lb/tree) for the three irrigation treatments for 1971-72 thru 1974-75 are listed (Table 3). The strongly biennial or irregular bearing trend exhibited existed prior to establishment of drip irrigation. During the three test seasons there were no significant differences in yield among the three irrigation treatments.

The percent of the crop smaller than size 96 at harvest is listed (Table 3). For each of the years there were no significant differences in fruit size distribution. The highest percent small fruit occurred in 1973, associated with the highest total yield while the lowest percent small fruit (1971) was associated with the lowest total yield. Growers are familiar with the relationship between fruit members and fruit size. In general the greater the number of fruit set the smaller the sizes at harvest. Data in this study indicate that within certain limits moisture levels are not the governing factor in fruit set or in ultimate fruit size.

In Fig. 1 the fruit growth curves for low, medium, and high rate of drip are compared to a curve obtained from three trees, in the same block, which received no irrigation in 1974.

Table 1. Class A pan evaporation for the Lower Rio Grande Valley and estimated drip irrigation water requirement for bearing citrus trees.

Month	Evaporation rate/day		Diam of tree canopy[3]	
			10 ft	15 ft
	Inches[1]	Gal/acre[2]	(Gal/tree/day)	
Jan	0.12	3258	6	9
Feb	0.15	4073	7	12
Mar	0.22	5974	11	17
Apr	0.28	7603	14	22
May	0.32	8689	16	25
June	0.33	8906	16	26
July	0.38	10319	19	29
Aug	0.38	10319	19	29
Sept	0.27	7332	13	21
Oct	0.22	5974	11	17
Nov	0.16	4345	8	12
Dec	0.12	3258	6	9

1 Average at Weslaco 1955-65 (5)

2 One acre-inch equals 27,154 gal.

3 Example of calculation:
10 ft diam = 78.5 sq ft canopy area = 0.0018 acre,
3258 gal/acre = x gal/0.0018 acre = 5.9 gal (entries in table rounded to nearest gal).

Table 2. Amount of water actually applied under several rates of drip irrigation and the annual rainfall 1972-74.

Rate	gal water/tree 1972	1973	1974
High	8800	8300	12,800
Medium	6600	6200	9,600
Low	4400	4100	6,400
ppt, inches	32.0	36.9	25.1

Table 3. Yield of red grapefruit under several rates of drip irrigation and percent of crop smaller than size 96, 1971-74.

Drip Rate	Total yield, lb/tree			
	1971[1]	1972	1973	1974
High	266	120	555	162
Medium	289	83	514	215
Low	273	52	567	227
	NS[2]	NS	NS	NS
	Percent of crop smaller than size 96			
High	16.5	4.5	40.9	5.7
Medium	14.5	4.1	40.2	8.0
Low	13.5	4.5	36.8	4.6
	NS	NS	NS	NS

1 Pre-drip uniformity trial, orchard received five flood irrigations.

2 NS = no significant differences within columns.

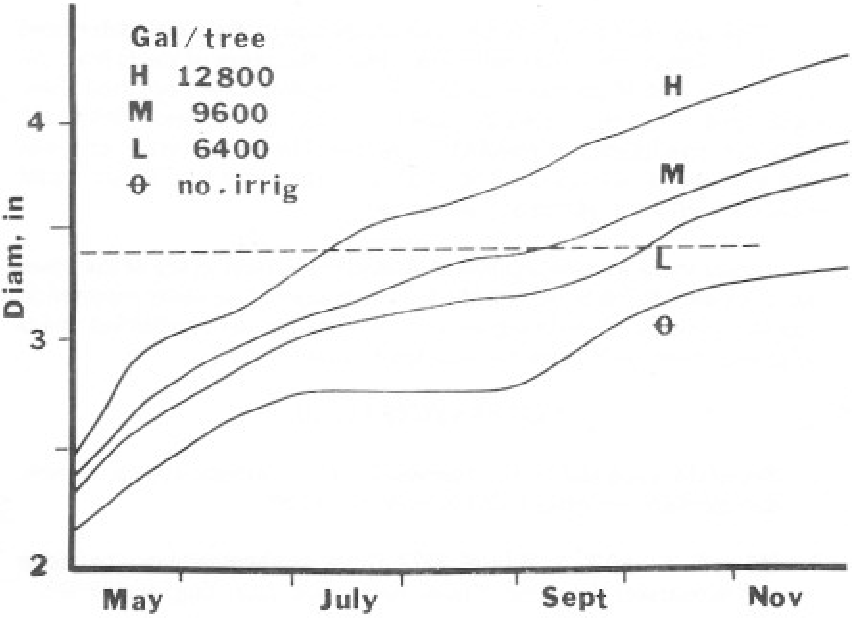

Fig. 1. Growth of red grapefruit May - December 1974 under several rates of water application. Dashed horizontal line indicates lower limit of 96 size fruit.

The high rate of drip reveals steady, rapid growth throughout the season with fruit attaining size 96 by mid-July. the curve for the medium rate indicates slower but steady growth. The low rate closely followed the medium early in the season but growth slowed in late summer. With the fall rains, growth increased sharply at the low rate. With the low and medium rates, the average fruit reached size 96 soon after the fall rains started.

Fruit growth on trees receiving no irrigation is a classic illustration of response to soil moisture changes. With the soil moisture carryover from the 39.4 inches of rain in 1973 and 6.5 inches through April 1974 these trees set a large number of fruit. Growth was slow but steady through early summer. From mid-July to mid-September there was a period 60 days with no effective precipitation and 6 weeks during which fruit diameter did not change. Growth resumed with the fall rains of 7.3 inches from 14 to 28 September, and 6.4 inches in October. In early December the average fruit on zero irrigation was approaching size 96.

Yield and size data indicate that in years of normal rainfall drip rate calculated from the pan evaporation formula can provide adequate moisture for production of a grapefruit crop. In years of greater than normal rainfall this rate is more than adequate. To determine drip rates for years of below normal rainfall will require experience from several dry seasons.

The portion of this block not in drip experiment remained under flood irrigation. Yields from these rows were within the range of yields from the drip rows in each of the years. In 1974 five irrigations were required. How great then, was the potential water savings under drip? With 100 trees/acre five irrigations equal 8100 gal/tree. The lowest rate of drip was 6400 gal/tree, a savings of 22%. With 125 trees/acre five floods would equal 6500 gal/tree, essentially no savings.

Since there were no significant differences in yield in any of the years the rates used failed to delimit the minimum amount of water required to maintain yields at the existing level. This study has been expanded and is being continued with lower rates of application.

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Chaff Scales and Their Parasites as Affected by Certain Acaricides During 1970-74

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ABSTRACT

A delayed increase in Chaff scales and a decline in parasite numbers followed spring applications of ethion (alone) or ethion-oil. The increased parasite activity following spring Omite[R] applications was related to a decrease in scale numbers. Single applications of Banomite[R] and Vydate[R] were followed by an increase and a delayed increase, respectively, in scale numbers with an increase and then a decrease in parasite numbers. Summer applications of ethion were followed by an increase in scale populations. Scale numbers generally declined after ethion was applied with reduced percentages of 415 paraffinic oil even though percent live scales increased or decreased; parasite numbers usually increased, or a delayed increase in numbers was found. Following summer Omite applications, scale populations increased three of five times. In all cases, scale numbers declined after an increase in parasites. Scales increased in numbers while reduced parasite activity was found after Vydate (increased parasite activity in one case), Carzol[R] and Trithion[R]. Banomite was followed by reduced scale numbers as related to increased parasite activity. Fall applications of ethion, ethion-oil, Omite, Vydate and Carzol were followed by reduced scale and parasite numbers while a small increase in scales was found after Banomite and Trithion.

Many pesticides have been investigated for their effectiveness solely in the control of various citrus mites. On numerous occasions, other potential pests of the athropod complex have increased to damaging numbers following such applications and were more difficult to control than the target pests. Knowledge of the selective action of various pesticides and their possible disruption of important pest-beneficial arthropod relationships are important considerations in the development of valid citrus pest management programs.

Chaff scale, *Parlatoria pergandii* Comstock, has been and is presently the most abundant and most widely distributed diaspidid scale insect on Texas citrus (1, 3). This investigation was initiated in 1970 to evaluate the possible effectiveness of various acaricides against chaff scale and their parasites. The acaricidal effects of most of the pesticides discussed herein have been reported previously (4).

MATERIALS AND METHODS

Spray materials were applied with a ground sprayer equipped with single nozzle guns, as well as with a tower gun above the tops of the trees using a total coverage technique (5).

Materials shown in the tables were used at the following rates (415 oil excepted) of their respective formulations per 100 gal of diluted mixtures: 4 oz 75.0% WP Banomite[R] (benzoyl chloride 2, 4, 6-trichlorophenyl) hydrazone; 6 oz 95.0% WP Carzol [R] (formentanate) (m[dimethylamino) methylene] amino phenyl methylcarbamate, hydrochloride; 6.3 oz 45.5% EC chlorobenzilate (ethyl 4, 4'-dichlorobenzilate); 0.83 lb 90.3% WP yellow cuprous oxide; 12.6 oz 46.5% EC ethion (0, 0, 0', 0'-tetraethyl S, S'-methylenebisphosphorodithioate); 23.6 oz 22.2% EC Guthion (azinphos-methyl) 0, 0-dimethyl phosphorodithioate S-ester with 3-(mercaptomethyl)-1, 2, 3-benzotriazin-4 (3H)-one); 12.6 oz 42.0% EC Kelthane[R] (dicofol) (4, 4'-dichloro-alpha- (trichloromethyl) benzhydrol); 99.65% 415 paraffinic oil (50% distillation point at 10 mm Hg) (Orchex 696); 1.5 lb 30.0% WP and 6.3 oz 80.0% EC Omite[R] (2- (p-tert-butylphenoxy) cyclohexyl 2-propynyl sulfite); 15.8 oz 46.24% EC Trithion[R] (carbophenothion S-[(p-chlorophenyl-thio)-methyl]0,0-diethyl phosphorodithioate); and 15.7 oz EC Vydate[R] (S-methyl 1- (dimethylcarbamoyl)- N- (methylcarbamoyl) oxy) thioformimidate). Sprint was added to the EC Omite to improve wetting.

The two-tree plots were replicated four times. Plot samples consisted of four scale-infested leaves from each quadrant for a total of 32 leaves per plot. Plots were comprised of orange trees, except that all plot sets had a single tangerine tree. Treatments A and C also had a single grapefruit tree.

Chaff scale and parasite populations were determined by a technique of examining no more than 10 second-stage, or older, female scales from each leaf until 100 scales were examined from each sample of 32 infested leaves (2, 3). Parasites were of an *Aphytis* complex, predominately *A. hispanicus* (Mercet). The internal parasite, *Prospaltella fasciata* Malenotti, was not found in sufficient numbers to report.

RESULTS AND DISCUSSION

In 1970, live scale percentages increased following summer applications of Carzol and ethion-oil, however, live scales/leaf decreased after the latter treatment (Table 1). Live scale numbers remained about the same following Guthion. A decrease in percent live scales (apparently associated with an increase in parasitism) was found 63 days after application of Carzol and Guthion. A parasite decrease was found after all treatments before an increase occurred. Percent live scales and live scales/leaf were higher following October Carzol than ethion-oil or Kelthane. Parasite numbers were less with a smaller scale population with ethion-oil than with Carzol or Kelthane.

In 1971, a decrease in scale populations was found during the first 41 days after May applications of Omite and ethion-oil with a large increase of parasites occurring in Omite plots (Table 1). Scale populations increased following Banomite. Later a reduction in scale numbers followed an

Table 1. Effect of spray treatments on populations of chaff scales and their parasites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		S[b]	P[c]	S/L[d]	S	P	S/L	S	P	S/L
07/07/70		35.6	4.8	1.3	26.0[e]	4.2	3.4	52.7	1.1	1.6
07/28		Carzol			ethion + 0.5 gal 415 oil			Guthion		
08/19	22	60.5	1.2	2.7	46.2	0.8	1.1	50.1	0.8	1.6
09/07	41	65.8	2.5	2.3	58.5	2.3	1.1	52.9	3.7	2.1
09/29	63	48.5	17.5	3.3	61.5	22.4	1.8	19.5	20.2	1.2
10/13		Carzol			ethion + 0.5 gal 415 oil			Kelthane		
01/18/71	97	18.8	7.8	1.5	2.0	2.4	0.04	16.2	4.5	0.9
02/16	126	30.5	4.2	2.4	1.5	0.0	0.03	10.0	1.8	0.6
05/17		42.2	10.0	3.9	26.6	1.4	0.7	28.5	7.2	1.3
05/19		WP Omite			ethion + 0.5 gal 415 oil			Banomite		
06/08	20	36.8	36.0	3.4	24.9	5.6	0.6	46.8	10.5	2.6
06/29	41	21.8	36.0	2.0	21.4	6.5	0.6	34.5	22.5	2.7
07/12	54	38.8	15.0	3.2	44.5	4.8	1.1	49.2	11.0	2.9
07/20		WP Omite			ethion + 0.5 gal 415 oil			Banomite		
08/16	27	21.0	19.0	2.0	28.5	13.1	0.8	29.2	34.0	2.4
09/21	63	28.0	13.2	2.6	44.8	17.5	2.4	40.0	21.0	3.4
10/26	98	17.0	12.8	0.7	9.2	15.6	0.3	6.2	11.0	0.5
10/27		WP Omite			ethion + 0.25 gal 415 oil			Banomite		
12/10	44	12.5	4.0	1.2	6.5	1.9	0.3	13.0	4.0	1.2
12/15								chlorobenzilate		
01/05/72	70	7.0	2.2	0.7	6.6	1.8	0.3	15.8	3.2	1.5
02/23	119	10.5	3.8	1.0	9.1	2.7	0.3	8.8	2.0	0.6

[a]Plots; [b]Percent live scales; [c]Percent immature *Aphytis* parasites; [d]Number live scales/leaf; [e]Insufficient scales for counts.

increase in parasite activity. An increase in scales and a decrease in parasite populations were found in all plots 54 days after application. Scale populations decreased, increased and then decreased in numbers following Omite, ethion-oil and Banomite application in July. Parasite numbers increased in all plots with a greater decrease in scale and parasite numbers in Banomite plots 98 days after application. A decrease in scale and parasite populations was found after October application of Omite and ethion-oil with an increase in scales and parasites 119 days later. Banomite application was followed with an increase in scales and a decrease in parasites. After chlorobenzilate was applied to these plots on 15 December, the scale population levels remained constant for 70 days before a drop in scale and parasite populations.

In 1972, reduced scale populations were found 35 days after the 5 April application of Omite and ethion-oil (Table 2). An increase in scale numbers occurred in the following 47 days while parasite numbers became

Table 2. Effect of spray treatments on populations of chaff scales and their parasites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		S[b]	P[c]	S/L[d]	S	P	S/L	S	P	S/L
03/29/75		32.2	7.0	2.9	36.8	7.9	1.5	15.5	7.0	1.2
04/05		WP Omite			ethion + 0.5 gal 415 oil			Vydate		
05/10	35	8.8	21.8	0.8	16.8	13.8	0.6	15.0	16.0	1.3
05/30	55	16.5	9.5	1.5	17.8	7.5	0.9	17.5	19.5	1.4
06/27	82	23.2	3.2	1.7	36.5	3.8	1.5	28.2	8.8	2.5
06/28		EC Omite			ethion + 1.0 gal 415 oil			Vydate		
07/25	27	38.0	6.0	3.6	36.5	2.8	1.4	38.5	1.8	2.9
08/10	43	36.8	14.2	3.3	23.8	10.0	1.3	58.5	4.0	4.9
08/15		EC Omite			ethion			Vydate		
09/14	30	21.5	21.5	2.2	27.5	9.8	1.8	65.2	7.0	6.2
10/17	63	15.2	10.8	1.2	30.5	17.8	1.4	23.8	37.0	2.2
10/17		EC Omite			ethion + 0.25 gal 415 oil			Vydate		
10/31	14	20.0	11.5	1.6	30.8	23.0	1.7	28.8	36.2	2.4
11/14	28	12.2	6.0	1.0	28.2	13.0	1.5	18.0	28.2	1.8
01/04/73	79	10.8	27.5	1.0	13.5	6.2	0.8	33.8	7.0	3.1

[a]Plots; [b]Percent live scales; [c]Percent immature *Aphytis* parasites; [d]Number of live scales/leaf.

smaller. No decrease in scale populations was found after Vydate while parasites were in sufficient numbers to affect the scale population through the 30 May count. Scale populations increased after the 28 June application of Omite and Vydate. The scale population remained constant 43 days after Omite while a sharp increase occurred in Vydate plots. Numbers of parasites in Omite plots were at least three times that found in Vydate plots. Scale numbers did not change 27 days after ethion-oil and decreased after 43 days while parasites increased in numbers. A small increase in scale numbers followed the 15 August application of ethion. Scale populations remained high following Vydate application. Scale numbers were much reduced after 63 days when increased numbers of parasites were found. A decrease in scale numbers followed a small increase after the 17 October applications of Omite and Vydate. A slow reduction in scale numbers was found after ethion-oil. After 79 days scale populations increased in Vydate plots with reduced numbers in other plots. An unusually large number of parasites for January were present in Omite plots.

In 1973, a delayed increase of scales was found after the 30 May Omite and ethion applications (Table 3). A sharp increase in scale

Table 3. Effect of spray treatments on populations of chaff scales and their parasites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		S[b]	P[c]	S/L[d]	S	P	S/L	S	P	S/L
05/27/73		22.8	8.8	2.2	27.7	9.0	1.3	14.0	3.8	1.3
05/30		EC Omite			ethion					
07/05	36	19.2	7.5	1.6	23.2	7.0	1.2	28.5	5.2	2.8
07/18	49	31.0	9.0	2.9	45.6	4.7	1.9	30.0	4.8	2.9
07/22		EC Omite			ethion			EC Omite		
08/22	31	70.2	11.0	6.7	68.4	7.3	3.2	37.2	9.0	3.3
09/26	66	21.8	27.8	2.2	22.2	37.8	1.7	25.5	44.8	2.6
10/30	100	17.2	9.5	1.6	25.8	14.0	1.8	20.8	9.0	1.9
11/02		EC Omite			ethion			chlorobenzilate		
11/21	19	17.2	10.8	1.6	22.0	6.0	1.6	24.0	11.0	2.2
12/19	47	16.5	7.0	1.6	14.0	5.0	1.2	10.5	9.2	1.0
01/16/74	65	16.2	3.0	1.6	9.5	2.2	0.7	13.2	5.2	1.3

[a]Plots; [b]Percent live scales; [c]Percent immature *Aphytis* parasites; [d]Number of live scales/leaf.

populations was found after the 22 July application of Omite and ethion while the increase in scales was not as great in C plots. The large increase of parasites by 26 September apparently produced the reduction in scale populations. Scale numbers remained constant following the 2 November application while a slow decline in numbers followed ethion. Following chlorobenzilate, scale populations decreased after 19 days with larger numbers of parasites in these plots than in ethion plots. Parasite numbers continually decreased.

In 1974, scale population counts showed an increase followed by a decrease and then an increase following 2 April application of Omite (Table 4). Scale populations were larger following chlorobenzilate than ethion-oil.

Table 4. Effect of spray treatments on populations of chaff scales and their parasites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		S[b]	P[c]	S/L[d]	S	P	S/L	S	P	S/L
03/07/74		27.0	2.5	2.6	16.2	2.2	1.5	26.0	3.0	2.3
04/02		EC Omite + copper			ethion + 0.5 gal 415 oil + copper			chlorobenzilate + copper		
04/26	24	38.8	10.0	3.8	14.5	3.2	0.9	29.2	10.8	2.8
06/05	64	19.2	11.5	1.6	18.2	1.2	1.1	34.5	14.0	2.6
06/18	77	37.8	4.0	3.4	37.7	1.8	2.0	42.0	5.0	3.1
06/19		EC Omite			ethion			Trithion		
07/11	13	58.5	5.0	5.7	43.0	0.8	3.6	58.5	0.8	5.7
08/02	44	47.8	10.0	4.7	46.2	3.0	4.4	44.8	2.8	4.4
08/22	64	62.2	1.5	6.2	63.2	0.8	5.9	66.8	0.8	6.7
09/27	100	34.2	24.8	3.4	31.5	23.5	3.2	31.8	17.0	3.2
11/06	140	19.8	11.8	2.0	18.0	9.8	1.8	9.5	5.8	1.0
11/14		EC Omite			ethion			Trithion		
12/19	35	16.5	4.2	1.6	12.5	2.0	1.2	18.8	1.8	1.8
01/03/75	50	15.0	3.0	1.5	6.5	0.8	0.6	15.0	2.0	1.5
01/16	63	5.2	0.2	0.5	11.8	1.5	1.2	11.8	0.5	1.2
02/03	81	11.5	0.5	1.1	12.0	1.0	1.1	13.0	1.8	1.3

[a]Plots; [b]Percent live scales; [c]Percent immature *Aphytis* parasites; [d]Number of live scales/leaf.

A slow increase occurred during the next 53 days. Parasites were more numerous in chlorobenzilate and Omite plots than ethion-oil plots. Scale numbers increased after 19 June applications of Omite, Trithion and ethion and live scales per leaf were greater during this period in all plots than at any time in this study. Fewer parasites were found than during the previous spring periods. Copper was added in the spring application to all plots and may have been associated with the larger scale populations. After 100 days the increased parasite activity had caused smaller scale populations. A decrease in scale numbers was found after 14 November application of Omite and ethion but an increase was found after Trithion. Scale numbers declined through January in all plots. A sharp decrease in parasites was found in all plots. More parasites were found during the 50 days after application of Omite than ethion or Trithion.

CONCLUSION

Generally, chaff scale populations increased after single post-bloom applications of Banomite and chlorobenzilate while a decrease or no change in numbers was found after Omite, ethion, ethion-oil and Vydate. Parasites increased in numbers except after ethion. After summer applications, scales increased after Omite, ethion, Carzol, Vydate and Trithion while scale populations remained static or declined after Guthion, ethion-oil and Banomite. Parasite numbers increased after summer Omite and Banomite; increased or decreased after ethion, ethion-oil and Vydate; and decreased after Carzol, Guthion and Trithion. After fall applications, both scale and parasite populations declined, as expected, but a small increase in scale numbers followed Trithion and Banomite.

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Control of Armored Scale
On Citrus With Non-oil Scalicides

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ABSTRACT

In spray trials on Marrs Early orange trees the non-oil scalicides-Lorsban[R] (0.5 lb ai/100 gal), Phosvel[R] (0.5 lb ai) and Supracide[R] (0.25 lb ai) controlled armored scale about as well as petroleum oil spray (Orchex 796) 1.50 gal. Limited control was obtained with Stauffer N-2596, azinphosmethyl and Cidial[R]. The insect growth regulators, CGA-13353, ZR-519, and ZR-619 did not effectively controlarmored scale in these trials.

Test plots of Marrs orange sprayed with a scalicide at postbloom and midsummer had significantly fewer armored scale than plots receiving the scalicide only in the summer application. Scalicide-acaricide tank mixtures of Lorsban + Plictran[R] or Supracide + chlorobenzilate controlled armored scale as effectively as oil + chlorobenzilate.

An oil + chlorobenzilate tank mixture (postbloom and midsummer applications) significantly reduced Texas citrus mite populations. A postbloom Supracide application followed by a midsummer Supracide + chlorobenzilate spray resulted in a significant increase in Texas citrus mite populations over the untreated control.

The basis of armored scale insect control on citrus in the Lower Rio Grande Valley has been petroleum oil sprays. Advantages of oil sprays over non-oil scalicides (e.g. azinphosmethyl) are: low cost, inability of target species to develop resistance, less harmful to beneficial insects, low toxicity to formulators and applicators, and supplementary control of Texas citrus mite, *Eutetranychus banksi* (McGregor), and greasy spot fungus, *Mycospaerella citri* Whiteside.

The most serious limitation to the use of petroleum oil sprays is their phytotoxic effect on citrus foliage and fruit. Most commonly occurring symptoms are leaf and fruit spotting, defoliation and fruit drop. Low humidity (30% or less), high light intensity and application to trees under severe moisture stress increases phytotoxicity.

Since the energy crisis the cost of petroleum oil sprays has more than doubled. This increased cost, coupled with the phytotoxic effects often resulting from oil spray use, has stimulated research in development and testing of non-oil scalicides. In 1973 and 1974 several new scalicides were tested at the Texas A & I University Citrus Center for control of armored scale, principally California red scale, *Aonidiella aurantii* (Maskell) and chaff scale, *Parlatoria pergandii* Comstock.

A tank mixture of petroleum oil spray and chlorobenzilate is currently used on Valley orchards for combined control of armored scale, citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), and Texas citrus mite, *Eutetranychus banksi* (McGregor). Some growers utilize this tank mixture in the postbloom (April-May) and early to midsummer (June-July) applications, while others include the scalicide only in the summer spray. Since there is some question as to the need of a scalicide in the postbloom application, an experiment testing several different orchard spray regimes was conducted to determine: (1) the effect of including a scalicide at postbloom and (2) the effect of different scalicide-acaricide tank mixtures on armored scale and mite populations.

MATERIALS AND METHODS

The scalicides used in these trials were: chlorpyrifos, 41.2% EC and 25% WP [0,0-diethyl 0-3,5,6-trichloro-2-pyridyl) phosphorothioate] (Lorsban^R); leptophos, 30.61% EC [0,2,5-dichloro-4-bromophenyl) 0-methyl phenylthiophosphate] (Phosvel^R); methidathion, 24.4% EC [0,0-dimethyl phosphorodithioate, S-ester-4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one] (Supracide^R); azinphosmethyl, 22.2% EC [0,0-diamethyl S-(4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl) phosphorodithioate] (Guthion^R); phenthoate, 46.5% EC [ethyl mercaptophenylacetate 0,0-dimethyl phosphorodithioate] (Cidial^R); Stauffer N-2596, 47% EC [0-ethyl S-(p-chlorophenyl) ethylphosphorodithioate]; formothion, 33% EC [0,0-dimethyl S-(N-formyl-N-methyl-carbomoylmethyl phosphorodithioate] (Vel 4282).

In certain trials the following insect juvenile hormone mimics or insect growth regulators (IGR's) were included: Zoecon ZR-512, 53% EC [ethyl 3,7,11-trimethyldodeca-2,4-dienoate] (Altozar^R); Zoecon ZR-619, 63.7% EC [ethyl 11-methoxy-3,7,11-trimethyldodeca-2,4-dienethiolate]; and Ciba-Geigy CGA-13353 40 0EC [chemistry not available].

The acaricides, chlorobenzilate, 45.5% EC [ethyl-4,4-dichlorobenzilate] (Acaraben^R) and Plictran^R, 50% WP [tricyclohexyltin hydroxide] were used in tank mixes with some of the previously listed scalicides.

1973 and 1974 Scalicide Trials. Preliminary scalicide trials were initiated in 1973 with: Phosvel, 0.5 lb and 1.0 lb (ai/100 gal); Vel 4282, 0.25 lb and 0.5 lb ai; and Lorsban, 0.5 lb ai. A single application of each treatment was made on three mature Marrs orange trees on 23 July. No scalicide applications had been made on test trees for a year prior to initiation of trials. Spray applications were made by handgun attached to a Hardie dilute sprayer (Hardie Manufacturing Company, Inc. Wilkes-Barre, Pa.) operating at 550 psi. Trees were sprayed to runoff, ca. 15 gal/tree.

In December, fruit samples were taken from sprayed and untreated (control) trees for fruit finish evaluations. From 30-40 fruit (equal numbers from exterior and interior branches at ca. the 5 ft level) were harvested from each tree. Each fruit sample was examined for any spray related blemishes and the number of armored scale counted. If 10 scale or less were counted on a fruit sample it was rated scale-free. Percent scale-free fruit was determined for each treatment.

In 1974, spray trials included several additional scalicides. Performance of these materials for scale control was compared to petroleum oil spray and a commonly used non-oil scalicide - azinphosmethyl. Trials were conducted on 8-year-old Marrs Early orange trees. The scalicide treatments and rates are given in Table 1. Treatments were completely randomized and each treatment replicated on 3-4 trees. Treatments were applied at postbloom (16 May) and again in midsummer (17 July). Methods of application, sampling at harvest and fruit finish evaluations were as previously described.

Where applicable, data were treated by analysis of variance and means separated by Duncan's multiple range test, P=0.05.

Scalicide - Acaricide Tank Mixtures. Supracide + chlorobenzilate and Lorsban + Plictran tank mixtures were compared to oil + chlorobenzilate for armored scale and mite control. Treatments and rates per acre are given in Table 2. Treatments differed in the scalicide-acaricide combination used and whether the scalicide was included in the postbloom application. A block of Marrs Early orange trees was divided into test plots of 35-40 mature trees each. Each treatment was applied to a separate test plot and all plots except the untreated control received spray applications at postbloom (21 May) and midsummer (17 July). A John Bean Model F-357 Speed Sprayer (John Bean Division, FMC Corporation - Lansing, Michigan) was used to make applications. Speed of the sprayer through the orchards was 1 mph with nozzle adjustment and pressure regulated to apply 250 gal per acre.

Armored scale and mite populations were monitored in all test plots beginning 20 May (pretreatment counts) and continuing at 3-4 week intervals (posttreatment counts) until 1 Oct 1974. Counts were made on the center four trees of each test plot. Crawlers and settled stages of armored scale were counted *in situ* on 5-10 fruiting terminals (fruit + adjacent leaves and twigs) selected at random throughout each tree. For each count two samples of 10 leaves each were also randomly picked from each tree and examined microscopically. One sample was used for Texas citrus mite counts, with the mean number of mites per leaf computed for each treatment. Percentage of leaves infested with citrus rust mites was determined from the second sample.

Table 1. Percent scale-free fruit harvested from Marrs Early orange trees sprayed with different scalicide treatments.

Treatment[1]	Rate[2]	% Scale-free fruit[3]
Petroleum spray oil	1.50	96.8 a[4]
Lorsban	0.50	90.0 ab
Phosvel	0.50	83.2 b
Supracide	0.25	81.0 b
N-2596	0.50	55.5 c
Azinphosmethyl	0.50	54.5 c
Phosvel	0.17	52.5 c
Cidial	0.25	44.3 cd
Cidial	0.125	40.2 cd
CGA-13353[5]	0.25	32.0 de
Control	-	22.2 ef
ZR-619[5]	1.00	17.8 ef
ZR-512[5]	1.00	16.7 f

1 Treatments applied at postbloom (16 May) and midsummer (17 July) with each treatment replicated on 4 trees.

2 Rate = lb ai/100 gal, except petroleum oil rate which is given in gal/100 gal.

3 At harvest (5 November) 30-40 fruit from each tree evaluated for armored scale. Fruit rated as scale-free if <10 scale present.

4 Numbers bounded by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

5 Insect Growth Regulator

Table 2. Average number of armored scale and Texas citrus mites for all posttreatment counts in test plots of Marrs Early orange trees sprayed with different treatments at postbloom and midsummer.

Test Plot[1]	Treatment[2] at: Postbloom	Summer	Average no: AS[3]	TCM[4]
A	Untreated Control	Untreated Control	79.7 a[5]	1.71 b
B	Plictran	Lorsban + Plictran	62.6 ab	0.76 bc
C	Chlorobenzilate	Oil + Chlorobenzilate	52.8 b	0.91 bc
D	Chlorobenzilate	Supracide + Chlorobenzilate	45.6 b	1.36 bc
E	Oil + Chlorobenzilate	Oil + Chlorobenzilate	33.7 c	0.31 c
F	Lorsban + Plictran	Lorsban + Plictran	27.4 c	0.39 bc
G	Supracide	Supracide + Chlorobenzilate	24.3 c	3.96 a

1 Each plot contained 35-40 mature Marrs Early orange trees.

2 Rates of chemicals used (lb ai/acre) were: chlorobenzilate = 1.5 lb, Lorsban = 1.25 lb; Plictran = 1.0 lb; Supracide = 1.5 lb; rate of petroleum spray oil = 10 gal per acre.

3 Average number of armored scale per terminal (Fruit + adjacent leaves and twigs).

4 Average number of Texas citrus mites per leaf.

5 Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, P = 0.05.

RESULTS

Scalicide Trials. The percent scale-free fruit from 1973 scalicide treatments was: Phosvel (0.5 lb) - 85% and Phosvel (1.0 lb) - 94%; Vel 4282 (0.25 lb) - 53% and Vel 4282 (0.50 lb) - 50%; Lorsban (0.50 lb) - 60%; and untreated control - 13%.

Comparative performance of the treatments applied in 1974 for armored scale control is given in Table 1. Petroleum oil spray and Lorsban were the most effective scalicides. No significant difference was found between these two treatments. Supracide and Phosvel (0.5 lb rate) also provided effective scale control with greater than 80% of the fruit free of armored scale. Limited control was obtained with N-2596, azinphosmethyl, Phosvel (0.17 lb) and Cidial. All were significantly better than the untreated control. The insect growth regulators CGA-13353, ZR-519, and ZR-619 did not effectively control armored scale in these trials.

Chaff scale was the predominant armored scale species counted, with limited numbers of California red scale and purple scale, *Lepidosaphes beckii* (Newman). No blemishes were found that could be directly related to any scalicide treatments.

Tank Mixtures. Test plots (E, F, G), which received scalicide at postbloom and midsummer, had significantly less armored scale than those plots receiving only a midsummer scalicide treatment (Table 2). California red scale and chaff scale, crawlers and early-stage settled nymphs, were already active in test trees (5-10 per terminal) on 20 May (pretreatment counts). The postbloom scalicide application apparently suppressed this early infestation and armored scale numbers were reduced in these trees throughout the trial. The non-oil scalicides, Lorsban and Supracide, were as effective as petroleum oil spray in these trials.

Results of Texas citrus mite counts showed only two treatments differed significantly from the untreated control (Table 2). Treatment E (oil + chlorobenzilate at postbloom and midsummer) significantly reduced the population. However, treatment G (Supracide at postbloom and Supracide + chlorobenzilate in midsummer) significantly increased Texas citrus mite numbers. This increase was greater than two-fold over the untreated control. A relatively high mite population (1.36/leaf) was recorded in the test plot sprayed with treatment D (chlorobenzilate at postbloom and chlorobenzilate + Supracide in midsummer).

Citrus rust mite counts were not analyzed because sufficient populations failed to develop in test plot trees, including untreated controls.

No phytotoxicity was observed at postbloom or midsummer on foliage or fruit in trees sprayed with any of the materials.

DISCUSSION

Control of California red scale and chaff scale was obtained with several non-oil scalicides - viz. Lorsban, Phosvel, and Supracide. Of these, only Supracide is currently registered for use on Texas citrus. Non-oil scalicides could provide citrus growers with needed alternatives to petroleum oil sprays for armored scale control.

Significantly fewer armored scale were counted in trees sprayed with a postbloom and summer scalicide application than were found where only a summer scalicide was applied. Armored scale populations are usually at highest levels in Valley orchards in summer months, although Dean and Shull (1) found peak levels of live California red scale at postbloom in 1969 to 1972. The importance of including a scalicide in the postbloom spray undoubtedly varies with the season and the individual orchard. An orchard is less likely to require a postbloom scalicide if it received an effective armored scale control program the previous season.

The present investigation has shown that populations of Texas citrus mite increase following the use of Supracide, particularly after repeated applications. Further studies are in progress to determine the reasons for, and the effect of, increased Texas citrus mite populations on citrus trees.

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Barnacle Scale: A Problem In Some Valley Orchards In 1975

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ABSTRACT

Barnacle scale, *Ceroplastes cirripediformis* Comst., was found in orchards in the La Feria-Adams Gardens and Mission-Texan Gardens areas. Some Valley citrus growers and orchard managers thought infestations were serious enough to warrant added chemical control measures. In several instances these were ineffectual and costly.

In April and May 1975, while monitoring for citrus mealybug, *Planococcus citri* (Risso), several orchards in the La Feria-Adams Gardens area were found to be infested with barnacle scale, *Ceroplastes cirripediformis* Comst. This scale seldom reached populations sufficient to cause economic damage in Valley orchards, undoubtedly having been controlled by beneficial insects (5), and pesticides used to control other citrus pests. However, in those orchards where barnacle scale was found their numbers were relatively high and warranted continued monitoring. Chemical spray programs used in some of these orchards were followed to determine their effectiveness in controlling the scale. Subsequently, other barnacle scale infestations were found in orchards in the Mission-Texan Gardens area.

This report presents information on barnacle scale identification, general life cycle and preliminary findings on its chemical control.

IDENTIFYING CHARACTERISTICS AND GENERAL LIFE CYCLE

Barnacle scale is an unarmored scale somewhat similar in appearance and life history to the Florida wax scale, *Ceroplastes floridensis* Comst. (1, 6). Morphological characteristics of the adult female and immature stages are rather outstanding, making it easy to identify and separate from other scale species found on Valley citrus.

The mature female is reddish brown and fits closely under a white waxy covering or test. An unusual spine-like process extends through the test at the anal end of the body. The test is divided into distinct angular plates, six on the sides and one on top (Fig. 1). Each plate has a central nucleus or spot, except the anal plate which has two spots. The mature female is ca. 5 mm long, 4 mm wide and 4 mm high. Because of their height the adult female and later stage nymphs are readily brushed or knocked from the leaf or twig surface. The test of the male has not been observed (2, 3, 4).

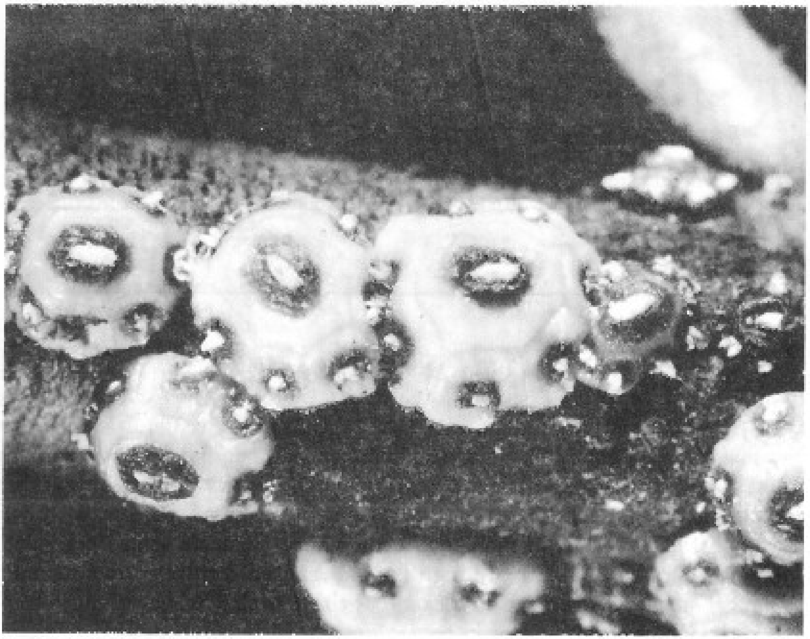

Fig. 1. Barnacle scale, *Ceroplastes cirripediformis* Comst., 14x.

The female scale deposits eggs beneath her body, which shrinks as the eggs accumulate. Eggs are reddish brown, with 100 or more deposited per female. Brown crawlers hatch from the eggs and migrate from under the female onto foliage and twigs. On leaves crawlers prefer the upper surface along the midrib, and become distinctly stellate as secreted wax accumulates on the body (Fig. 2). The nymphs are white at first but as development continues they become a mottled brown with white tuft-like structures projecting from the test (Fig. 3). When the adult stage is reached the test becomes a grayish-white in color. All stages of the barnacle scale are motile, except the adult female when it is depositing eggs. Completion of the life cycle requires ca. three months.

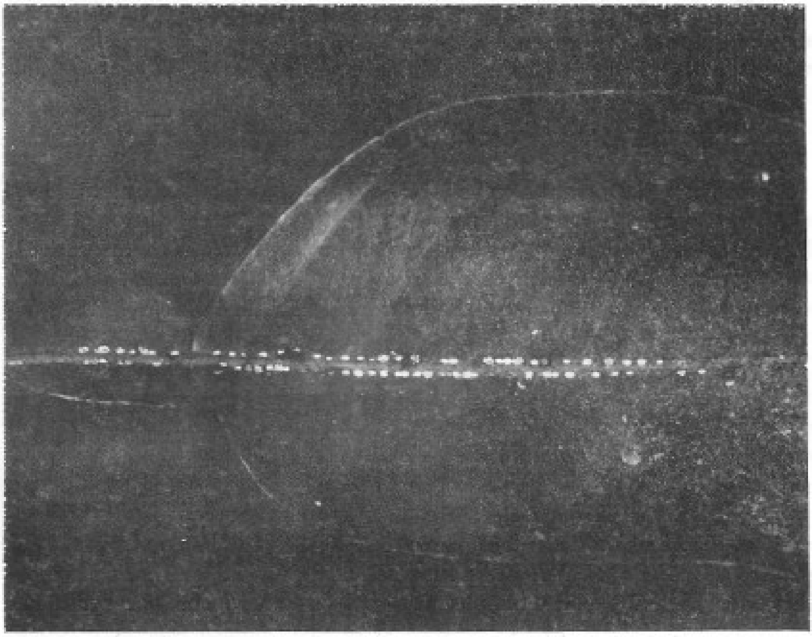

Fig. 2. Stellate nymphs of barnacle scale congregated along midvein of grapefruit leaf.

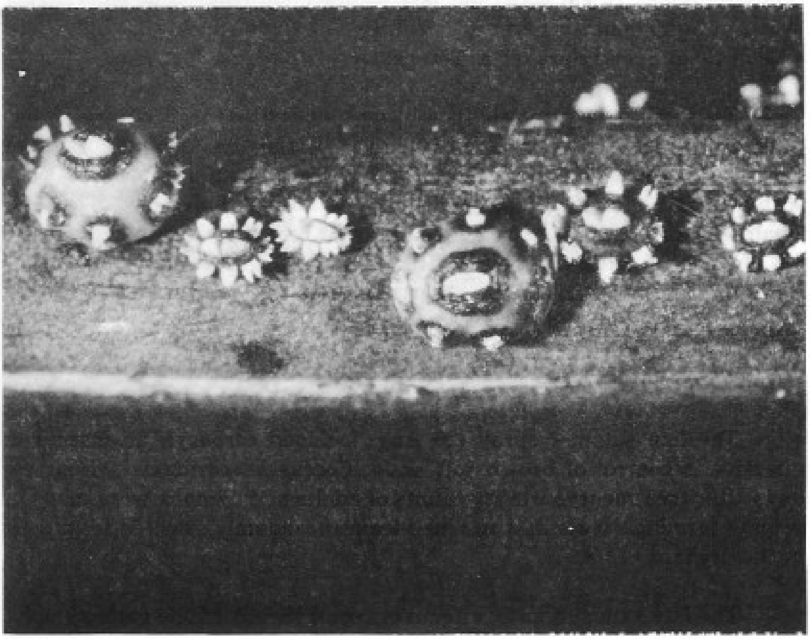

Fig. 3. Various life stages of barnacle scale. 14x.

Two broods of crawlers were observed, one in April to early May and a second in mid to late August. Barnacle scale secretes large amounts of honeydew which attract ants and provides a growth medium for sooty mold fungus.

CHEMICAL CONTROL OF BARNACLE SCALE

Most orchards in which barnacle scale were found had been under a chemical spray program for mite and insect control. Some had a previous history of heavy citrus mealybug infestations. The 1975 spray program in most orchards included spray applications at postbloom (April-May), summer (June-July) and late summer or early fall (Aug-Sept). A few orchards received additional sprays specifically for barnacle scale control. The following descriptions are of two orchards in the Adams Gardens area, which were moderately infested with barnacle scale, but received different chemical spray programs during the 1975 season. Observations were made on the comparative effectiveness of the two control programs.

On 24 April a barnacle scale infestation was found in a grapefruit orchard 3.5 miles southeast of La Feria. Of 200 leaves sampled (20 leaves on each of 10 trees) 23% were infested, with an average of 4 barnacle scale per leaf. Early stage stellate nymphs were the principal forms observed. The following chemical sprays were applied to this orchard (per acre rates): postbloom (2 May)--3 pt chlorobenzilate (Acaraben^R^), 10 gal citrus spray oil, 7 lb copper hydroxide (Kocide^R^); summer spray (16 June)-- 3 pt chlorobenzilate, 12 gal spray oil; late summer (26 Aug)--3 pt chlorobenzilate, 2 gal spray oil, 7 lb carbaryl (Sevin^R^). All applications were made with a John Bean Speed Sprayer at 250 gal/acre.

Fourteen days after the postbloom application barnacle scale were difficult to find, with an estimated 3% of the leaf samples infested. However, a count on 9 June showed populations again increasing in trees with many later stage nymphs and some adult females observed. The early summer spray substantially reduced crawler and early stage nymphs but did not control adults. By early August numerous trees were black with sooty mold, particularly in a western section of the orchard. Twigs were covered with adults and later stage nymphs, while crawlers predominated on leaves. Greatly increased numbers of crawlers indicated eclosion of a second brood of barnacle scale during August.

The late summer spray (26 Aug) included carbaryl, an insecticide effective in control of brown soft scale, *Coccus hesperidum* L. Fourteen days after treatment mortality counts of adults and nymphs were made on growth terminals (twig and attached leaves) randomly selected from trees in the orchard.

The late summer spray effectively controlled barnacle scale nymphs, with ca. 94% mortality, but was less effective on adults, with 81% mortality (Table 1).

Table 1. Barnacle scale mortality in two orchards sprayed with different pesticide tank mixtures.

Location of Infested Orchard	Treatment[1]	% Mortality[2]		
		Nymphs	Adults	Mean
SE La Feria	Carbaryl[3]	93.8	80.6	87.2
NE La Feria	Methidathion[4]	92.7	99.7	96.2

1 Treatments applied 26-28 Aug, 1975 by air blast sprayer at 250 gal/acre.

2 Based on microscopic examination of 50 growth terminals (twigs + adjacent leaves) randomly selected from respective orchards 14 days after treatment.

3 7 lb carbaryl (Sevin[R]) combined with 3 pt chlorobenzilate (Acaraben[R]) and 2 gal citrus spray oil in 250 gal water/acre.

4 4 pt methidathion (Supracide[R]) combined with 3 pt chlorobenzilate and 1 qt spreader-sticker in 250 gal water/acre.

In a second grapefruit orchard, 4 miles northeast of La Feria, a concerted effort was made to control barnacle scale through additional chemical spraying. A postbloom application (16 April) of 3 pt chlorobenzilate + 7.5 gal citrus spray oil + 7 lb Kocide (rate/acre) was followed by a 2 June application of 10 lb Zineb + 7.5 gal oil. Pesticides were applied with an air blast sprayer at 250 gal/acre. While there was limited control of young barnacle scale neither application was effective on adults. Therefore, on 7 July an application was made of 3 pt chlorobenzilate + 7.5 gal oil + 4 pt of dimethoate (Cygon[R]). Inclusion of the latter insecticide, an organophosphate, enhanced effectiveness and resulted in an adult mortality of about 50% . Based on this limited success a second application of 4 pt dimethoate + 1 qt of spreader-sticker was made in early August. This spray, while providing some control of nymphs and adults, had no apparent effect on the egg stage, since a substantial second brood of barnacle scale crawlers developed in mid-August.

On 28 August, a final summer spray of 3 pt chlorobenzilate + 4 pt methidathion (Supracide[R]) + 1 qt spreader-sticker was applied to the orchard. Methidathion, an organophosphate insecticide, was added specifically to determine its effecitveness on barnacle scale. When a mortality count was made 14 days after treatment, few live scale were found.

Mean percent mortality (adult and nymphs) was 96%, with an exceptionally high adult mortality of 99.7% (Table 1). However, some of the recorded mortality was undoubtedly barnacle scale that had been killed by a prior spray and which remained attached to the foliage.

The need exists not only for further research on chemical control, but also on biological control agents as well. Numerous parasitized barnacle scale were observed, often with the insect parasite still within the host. Identification of these beneficial species is now in progress.

ACKNOWLEDGEMENTS

We thank Mr. Joe Garcia Jr. and Mr. Carlos A. Diaz for technical assistance. We also express our thanks to Mr. W. G. Hart, Research Leader, USDA-ARS Citrus Insects Research Laboratory, Weslaco, TX, for submission of barnacle scale specimens for species verification to USDA-ARS Systematic Entomology Laboratory, Beltsville, Maryland.

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Comparative susceptibility of Star Ruby grapefruit to Phytophthora Foot Rot

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ABSTRACT

Observation of natural infection by *Phytophthora parasitica* in a randomized experiment in the nursery revealed no differences in foot rot incidence on Star Ruby and old-line red grapefruit. No differences were observed in foot rot severity on these cultivars following trunk inoculations with mycelial plugs placed beneath the bark. Thus, there is apparently no difference between the two cultivars in the rate of infection of unsuberized bark or in the rate of lesion expansion once infection has occurred.

In an orchard experiment comparing artificial zoospore inoculation and natural infection, Star Ruby was more frequently infected and more severely damaged than old-line red. The more frequent infection of Star Ruby was attributed to a larger number of growth cracks on suberized trunks of this cultivar. The more severe damage on Star Ruby was apparently due to the inability of this cultivar to rapidly wall-off wounds or foot rot infections.

'Star Ruby' grapefruit (*Citrus paradisi* Macf.) is a seedless, deep-red-fleshed cultivar derived from the seedy 'Hudson' grapefruit (1). Budwood was released to Texas nurserymen in 1970 and approximately 1200 ha of this cultivar have been planted. From the outset, foot rot, caused by *Phytophthora parasitica* Dast. [*P. nicotianae* var. *parasitica* (Dast.) Waterhouse], was frequently observed in nurseries and substantial tree losses occurred in some Star Ruby orchards from this disease.

This study was undertaken to determine the relative susceptibility to foot rot of Star Ruby grapefruit compared to other varieties commonly grown in Texas.

MATERIALS AND METHODS

To compare the susceptibility of Star Ruby grapefruit to that of other citrus species and hybrids, 'Marrs Early' orange [*C. sinensis* (L.) Osb.]; Star Ruby and old-line 'Riddle Red Gold' grapefruit; 'Troyer' citrange [*C. sinensis* x *Poncirus trifoliata* (L.) Raf.] were budded on sour orange (*C. aurantium* L.) rootstock in a nursery naturally infested with *P. parasitica*. The budded trees were arranged in a randomized complete block design with 20 replications of each species or hybrid. An unbudded sour orange seedling was included in each replicate for comparison with the budded trees. The number of active (gumming) foot rot lesions on the scion and on the rootstock was recorded seven months after budding.

Fourteen months after budding, the trees in the above experiment which were free from natural foot rot infection on the scion were artificially inoculated with *P. parasitica*. From 9-16 trees of each citrus species or hybrid were inoculated with a local isolate of *P. parasitica*, S-8 (3), growing on clarified V-8 juice agar (4). A 1-cm diameter disc of bark was removed 10-15 cm above the budunion on each tree, a plug of agar bearing the fungus inserted, the disc of bark replaced, and entire area wrapped with plastic tape. The tape was removed five days after inoculation. Foot rot severity was rated on each tree two months after inoculation using the following scale: 1 = no infection; 2 = small lesion (tree 10-25% girdled), healed; 3 = small lesion, gumming; 4 = moderate lesion (tree 25-50% girdled), gumming; 5 = large lesion (tree more than 50% girdled), gumming.

A second experiment was designed to compare the susceptibility of Star Ruby and old-line red grapefruit to artificial and natural infection under orchard conditions. The experiment was conducted in a 2-year-old orchard where Star Ruby and old-line red grapefruit on sour orange rootstock were interplanted in each row. Four different treatments were used and each treatment was replicated 15 times on each cultivar. Treatments were arranged in a randomized complete block design. The orchard soil was infested with *Phytophthora* which was probably introduced with the nursery stock when the orchard was planted. The following treatments were used: 1) trees wounded, inoculated and banked with soil; 2) trees wounded and banked only; 3) trees banked only; 4) trees uninoculated and unbanked. Trees were wounded by making four vertical cuts on each side of the trunk through the bark to the cambium and extending upward 8-10 cm from the budunion. The method of inoculation was similar to that used by Whiteside (7) for orchard trees. Trunks were wrapped with a wet, 4 x 27-cm absorbent cotton strip. Mycelium and zoospores of a local isolate, B-2 (3), were produced as described previously (4). The suspension of zoospores and mycelium produced in one Petri dish culture was poured onto the cotton strip on each tree. To bank trees, soil was mounded around the trunk to a height of 40-50 cm. After treatments were completed the orchard was flood irrigated with about 15 cm of water. Soil banks and cotton strips were removed one week after treatment. The number of active infections on each tree was counted 2, 6, and 12 weeks after treatment.

Where appropriate, data were treated by analysis of variance and means were separated by Duncan's Multiple Range Test.

RESULTS

Small differences were observed in the incidence of natural infection on trees of various citrus species and hybrids (Table 1). Marrs Early orange had the highest number of infections and Troyer citrange the fewest. Sour orange seedlings had a large number of infections, but all of the lesions were small. Artificial inoculation of trees of the same species and hybrids gave similar results (Table 2). Troyer citrange and sour orange were only slightly affected, Marrs Early orange was more severely affected, with the grapefruit cultivars intermediate. The results are consistent with relative susceptibility of different species and hybrids of citrus reported elsewhere (2, 5). No significant difference in natural or artificial infection between the two grapefruit cultivars was observed.

Differences were observed between Star Ruby and the old-line red grapefruit when different treatments were made under orchard conditions (Table 3). When trees were wounded, inoculated, and banked, no difference in the rate of infection was noted on the two cultivars after 2 weeks. However, 12 weeks after inoculation most of the lesions on the old-line trees had healed, while 1/3 of the lesions on Star Ruby were still active. When trees were wounded and banked only, Star Ruby was more frequently infected than the old-line two weeks after treatment. When trees were banked only or were not treated, there was no difference between Star Ruby and the old-line 2 or 6 weeks posttreatment. By 12 weeks after treatment, Star Ruby had significantly more infections than the old-line regardless of the treatment.

Distinct differences between treatments on the same cultivar were apparent 2 weeks after the initiation of the experiment, but with recovery of some lesions and new infections which occured, no differences were apparent after 12 weeks.

Table 1. Incidence of natural infection by *Phytophthora parasitica* on several citrus species and hybrids budded on sour orange rootstock.

Species and Cultivar	Trees[1] with foot rot on:	
	Scion	Rootstock
Marrs Early orange	5	6
Riddle Red Gold grapefruit	3	4
Star Ruby grapefruit	2	7
Troyer citrange	1	4
Sour orange seedlings	-	10

1 Number of naturally infected trees out of 20 of each species or hybrid arranged in a randomized complete block design.

Table 2. Foot rot severity on several citrus species and hybrids following artificial trunk inoculation with *Phytophthora parasitica*.

Species and Cultivar	Severity Rating[1]
Marrs Early orange	2.69a[2]
Riddle Red Gold grapefruit	2.42a
Star Ruby grapefruit	2.13ab
Sour orange seedlings	1.60 b
Troyer citrange	1.57 b

1 Based of 9-16 inoculated trees of each species or hybrid which were rated on the following scale: 1 = no infection; 2 = small lesion, healed; 3 = small lesion, gumming; 4 = moderate lesion, gumming; 5 = large lesion, gumming.

2 Mean separation by Duncan's Multiple Range Test, P = 0.05.

DISCUSSION

Initial results (Tables 1 and 2) indicated no differences between Star Ruby and old-line red grapefruit either in the incidence of natural infection or in the extent of damage on artificially inoculated trees. On the young, unsuberized bark of nursery trees, where *Phytophthora* can penetrate directly (6), no differences were observed in the rate of infection between Star Ruby and old-line red. Likewise, once *Phytophthora* had been placed beneath the bark, no differences were observed in the rate of lesion expansion on the two cultivars. However, in the orchard experiment (Table 3), the rate of infection on Star Ruby was higher than on old-line red grapefruit where trees were banked with soil or untreated. Since wounds or natural openings are required for *Phytophthora* infection on suberized trunks (6), the higher incidence of infection on Star Ruby may have been attributable to a larger number of growth cracks on this vigorous, nucellar cultivar.

The main difference between Star Ruby and old-line grapefruit seems to be in the ability to wall-off wounds and infections. The greater number of active infections on Star Ruby in the orchard experiment (Table 3) where trees were wounded and banked may be attributable to the inability of this cultivar to rapidly establish barriers around wounded or infected areas. In the same experiment, where trees were inoculated, almost all infections on old-line red grapefruit healed after 12 weeks, while many on Star Ruby remained active. While Star Ruby is somewhat more likely than old-line red grapefruit to become infected by *Phytophthora* it is much more likely that Star Ruby trees will succumb once they become infected.

Table 3. Effect of wounding, artificial inoculation, and banking of trees with soil on the infection of Star Ruby and old-line red grapefruit by *Phytophthora parasitica*.

Treatment	Cultivar	No. of active infections/tree after:		
		2 weeks	6 weeks	12 weeks
Wounded,[1] Inoculated,[2] Banked[3]	Star Ruby	1.87 a[4]	1.73a	0.60a
	Old-line red	1.80 a	1.27 b	0.07 b
Wounded, Banked	Star Ruby	0.73 b	0.13 c	0.27 a
	Old-line red	0.13 c	0.07 c	0.00 b
Banked	Star Ruby	0.13 c	0.20 c	0.47 a
	Old-line red	0.00 c	0.00 c	0.07 b
Control	Star Ruby	0.13 c	0.07 c	0.27 a
	Old-line red	0.00 c	0.00 c	0.07 b

1 Four 8-10 cm vertical cuts just above the budunion on each tree.

2 Trunk wrapped with a wet cotton strip and inoculated with a suspension of zoospores and mycelial fragments.

3 Soil mounded around the trunk to a height of 40-50 cm.

4 Means in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range Test, $P = 0.05$.

Despite the foot rot problem on Star Ruby grapefruit, this cultivar appears to be no more susceptible than Marrs Early orange and can be grown successfully if proper measures are taken. Nurserymen should fumigate infested soils before planting and bud trees at least 15 cm above the soil line. Growers should purchase only nursery stock free from *Phytophthora* and avoid planting in areas with poor drainage.

ACKNOWLEDGEMENT

I wish to thank Mr. Santiago Villarreal for his excellent technical assistance.

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Identification of Citrange Stunt Virus from Meyer Lemon in Texas

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ABSTRACT

Citrange stunt virus was identified from a Meyer lemon tree on the basis of graft transmission of the virus to Mexican lime (*Citrus aurantifolia*) and citranges (*Poncirus trifoliata* x *C. sinensis*), and mechanical transmission to bean (*Phaseolus vulgaris* 'Red Kidney'). The virus produced blotchy spotting on leaves of Mexican lime, leaf spotting and stunting of citranges, and necrotic local lesions on Red Kidney bean.

Tatter leaf was originally described by Wallace and Drake (8) as a disease causing blotchy spotting on leaves of Mexican lime, *Citrus aurantifolia* [Christm.] Swing. and tatter-leaf symptoms on *C. excelsa* Wester. The virus was identified from Meyer lemon [*C. limon* (L.) Burm. f.] which is a symptomless carrier (8). Graft inoculations with bark from tatter-leaf infected Meyer lemons produced leaf spotting, leaf and stem distortion and stunting on citranges [*Poncirus trifoliata* (L.) Raf x *C. sinensis* (L.) Osbeck] and citremons (*P. trifoliata* x *C. limon*) (9). Later, evidence was presented (10) that infected Meyer lemons carry two viruses, one causing symptoms on citranges and called citrange stunt virus (CSV) and the other causing tatter leaf on *C. excelsa* and called tatter leaf virus (TLV).

Yarwood (12) mechanically transmitted a virus from Meyer lemon to herbaceous plants and called it Meyer lemon latent virus. Semancik and Weathers (5) transmitted a virus from tatter-leaf-infected Meyer lemon to cowpea [*Vigna sinensis* (Torner) Savi] and purified a flexuous rod-shaped virus from infected cowpeas. These viruses are probably identical to CSV (1). Garnsey (3) transmitted TLV mechanically from citron (*C medica* L.) to *Nictotiana clevelandii* Gray and back to citron.

The TL-CSV complex was probably introduced into the United States with the original introduction of Meyer lemon in 1908 (8). A high percentage of the Meyer lemons in California (9) and in Florida (2) carry the TL-CSV complex. The virus complex has not been found naturally in citrus other than Meyer lemon (8), but it causes budunion crease, stunting, and decline of infected trees budded on citranges and other trifoliate orange hybrids (2, 10).

This paper describes the identification of a virus recovered from a Meyer lemon tree in Texas.

METHODS AND RESULTS

Citrus seedlings were grown in sand culture in the greenhouse. Plants were fertilized and graft inoculations made by previously described methods (7). Beans (*Phaseolus vulgaris* L. 'Red Kidney') were grown in a growth chamber at 20-25 C with 12 hr light daily. They were mechanically inoculated by rubbing the leaves with a macerate prepared by grinding infected Mexican lime leaves with a mortar and pestle in 0.1 M phosphate buffer, pH 8.0.

In the course of routine indexing of Meyer lemons for tristeza, a Mexican lime indicator plant was found with blotchy spotting on the leaves and feathering of the veins (Fig. 1a) in addition to vein-clearing symptoms.

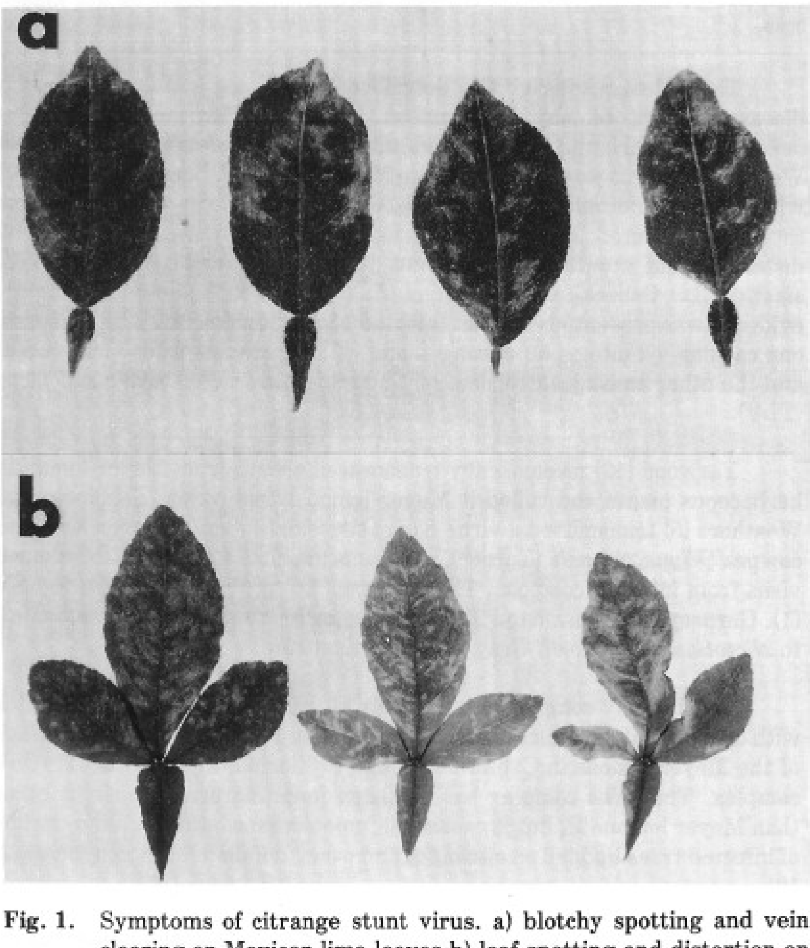

Fig. 1. Symptoms of citrange stunt virus. a) blotchy spotting and vein clearing on Mexican lime leaves b) leaf spotting and distortion on Troyer citrange.

Since these symptoms were similar to those of tatter-leaf (9), inoculations of other hosts were made to confirm the diagnosis. Three seedlings each of Bessie sweet orange (*C. sinensis*), Troyer citrange, and Mexican lime and three budlings each of *C. excelsa* on sour orange (*C. aurantium* L.) rootstock were grafted with two bark patches each from the infected Mexican lime seedling. All Mexican limes developed symptoms similar to those of TLV on that host (9). All inoculated Troyer citrange seedlings showed leaf spotting and distortion (Fig. 1b), curvature of the stems and were stunted compared to healthy controls. One of the *C. excelsa* plants showed slight tattering of the leaf edges and some spotting on one occasion while the other two plants showed no symptoms. Inoculated sweet orange seedlings remained symptomless.

In another experiment, three seedlings each of Troyer citrange, Morton citrange, Mexican lime and 12 seedlings of *C. excelsa* were graft-inoculated with two bark patches each from the original, infected Meyer lemon. All of the Troyer and Morton seedlings developed typical symptoms of citrange stunt (1), but none of the *C. excelsa* nor Mexican lime seedlings developed any symptoms during the 12 months following inoculation. In the third experiment, where seedlings were graft inoculated from the original infected Meyer lemon, 5 of 6 Rusk citrange, 5 of 6 Troyer citrange and 0 of 9 *C. excelsa* seedlings showed symptoms in the 12 months following inoculation. When the source of inoculum was an infected Troyer citrange seedling, 5 of 6 Rusk citrange, 1 of 3 Troyer citrange and 0 of 6 *C. excelsa* seedlings showed symptoms.

Mechanical transmission of the virus from graft-inoculated Mexican lime to Red kidney bean was successful. Small necrotic local lesions were produced on the primary leaves about 5-7 days after inoculation.

Only a single Meyer lemon tree was found to be infected with CSV. Mexican lime seedlings graft-inoculated with bark from two other Meyer lemons at the same site and presumably from the same budwood source showed no symptoms. Fourteen other Meyer lemon trees previously indexed for tristeza on Mexican lime seedlings showed no indication of infection with the TL-CSV complex although two were found to be infected with tristeza.

DISCUSSION

The virus encountered in the Meyer lemon tree appears to be CSV. The typical CSV symptoms on Morton, Rusk, and Troyer citranges and the local lesions produced on Red Kidney beans indicate the presence of CSV (4). Faint symptoms similar to those of tatter leaf were observed on one occasion on a single inoculated *C. excelsa* plant, but were not sufficiently distinct to confirm the presence of TLV in this source. TLV was previously detected in a Meyer lemon introduced into California from Texas in 1958 (8).

The TL-CSV complex is not known to occur naturally in varieties other than Meyer lemon. Even in Meyer lemon, CSV does not appear to be common in Texas and its presence was confirmed in only one tree. However, since transmission from the infected Meyer lemon was erratic, further indexing might reveal that the virus is more widespread than is presently indicated. The rarity of TL-CSV in Texas Meyer lemons may be due to extensive propagation of the Rickett's Meyer lemon which is free of tristeza (6) and probably also of TL-CSV.

In spite of the rarity of the TL-CSV complex in Texas citrus, efforts should be made to avoid contaminating commercial budwood sources with the virus especially since citrumelos which are potentially good rootstocks for Texas (11) are susceptible to the virus (10).

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Acreage of Vegetables in Hidalgo County in 1972 and 1973

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ABSTRACT

From the fall of 1972 through the spring of 1974 ground surveys of approximately 1400 fields in Hidalgo County, Texas, provided a replicated sample that permitted us to calculate acreage estimates and standard errors of the estimate for 18 vegetable crops produced in the county.

Previously unavailable acreage estimates are tabulated for seven crops (bean, beet, mustard greens, turnip, parsley, peas, and squash) along with comparative acreages for nine others (broccoli, cabbage, carrot, cantaloupe, cucumber, lettuce, onion, green pepper, and tomato) that are routinely estimated by the Texas Crop and Livestock Reporting Service (TCLRS). Although ground survey consistently overestimated the acreage of onion and tomato as compared with the TCLRS estimates and inadequately sampled the acreages of melon and potato in the northern and western part of the county, about 15 vegetable crops were estimated representatively. Since the acreage of citrus, cotton, grain sorghum, and other commodities can be estimated from the same survey as vegetable acreages, various commodity organizations would profit from jointly sponsoring such surveys. A survey in April for the warm-season crops and one in December for fall-planted crops would suffice.

Hidalgo, County, Texas, has been a test site for developing a data analysis system and for investigating the feasibility of assessing agricultural land uses and growing conditions from data acquired by the first Earth Resources Technology Satellite (ERTS-1) (1, 2, 3, 6). A complete county was chosen as the base unit for these studies since it is the governmental unit by which agricultural census data are collected and summarized and by which crop allotment and acreage limitations are administered. Extensive observations of crop and soil conditions (ground truth) in individual fields representative of the county were acquired and compared for reliability and accuracy with the ERTS-1 data interpretations. These data provided the detailed set of periodic data used in this paper for statistically estimating the acreage devoted to each vegetable crop in Hidalgo County.

The data are important for two reasons. First, we directly observed what cron occupied individual fields, whereas official estimates of the Texas Department of Agriculture and the Statistical Reporting Service (SRS) of the USDA (5, 6) are based on inquiries to shippers and growers. Thus, with these data we could compare acreage estimates using two independent data acquisition techniques. Second, the observations were made at approximately 3-week intervals from September through April, which permitted us to determine the optimum dates for estimating the acreage of specific crops.

METHODS

Statisticians of the SRS, USDA, Washington, D. C., designed and designated a sample of land areas (segments) from within the county to estimate county-wide crop acreage.

Hidalgo County was divided into three major agricultural regions--the northern, central, and southern. The northern region is devoted to ranching enterprises with land used mainly for pasture and range. The central region is predominantly cultivated irrigated land, generally small fields of typically medium-textured terrace soils devoted to mixed field and row crops, citrus, and miscellaneous farm enterprises. The southern region is mostly fine-textured soil used extensively for winter vegetable production. Urban areas, most numerous in the central region, and bodies of water were excluded from the segments selected.

For sampling, the central and southern regions were divided into approximately 160-acre segments and the northern region into approximately 1,000-acre segments along property lines and each segment was assigned a number. By the random start and increment method, we selected four interpenetrating samples (43 segments each) distributed through all three regions. An additional 25 segments were chosen in the sourthern region because of its high concentration of winter vegetables. A total of 197 sampling segments was chosen from the 3,927 segments listed for the county. The sampled area totaled 42,000 acres, approximately 4% of the 980,000-acre land area of the county.

Our sampling method permitted us to summarize observations by regions if desired. The regional totals can be composited to obtain county-wide estimates.

Each segment designated a sampling was located on a base aerial map and assigned a number. Individual fields (plots of land devoted to the same crop or use and managed uniformly within each segment) were numbered, also, on the base aerial map. The total number of fields we observed was about 1,400.

The ERTS-1 satellite launched on 22 July 1972, passes over the Rio Grande Valley of Texas every 18 days. Ground truth collection was synchronized with the satellite passage to insure observation of concurrent ground conditions. Ground observations were made of crop species, plant height, percent ground cover, and phenological stage of crop development. Crops were designated as soon as identifiable from emerged seedlings. We also used auxiliary comments and notes on tillage and land preparation for planting, cultivation practices, soil surface moisture conditions, number of harvests, and post-harvest tillage.

The ground truth surveys were made within five days of the following dates (month/day) in each year:

1972 - 8/30, 9/17, 10/5, 10/23, 11/10, 12/16.
1973 - 1/21, 4/21, 5/9, 5/27, 9/12, 9/30, 10/18, 11/5, 11/23, 12/11, 12/29.
1974 - 1/16, 2/3, 2/21 3/11, 3/29, 4/16.

The survey dates were deliberately selected to encompass the 1972 and 1973 fall-winter, and the spring of 1973 and 1974 vegetable production seasons.

After each field visit, the field survey information was coded and entered on 80-column computer punch cards. This information was edited for completeness, checked for consistency against other periodical observations, and transferred to magnetic tape for retrieval and use in analysis and summarization.

The 1972 and 1973 vegetable acreage estimates made by TCLRS (4, 5) are used for comparison and discussion.

RESULTS AND DISCUSSION

Table 1 compares the acreages for nine vegetables estimated from our ground observations with estimates published by TCLRS. The table also contains estimates by the TCLRS for six vegetables not observed in our ground sampling (cauliflower, sweet corn, honeydew melon, spinach, watermelon, and potato), and a category, "other vegetables", that includes those contracted for processing. For the ground survey data, vegetables grown for processing were not distinguished from those for fresh market. Our observations also contain information on seven vegetables (bean, beet, mustard greens, turnip, parsley, peas, and squash) for which TCLRS does not estimate acreages.

Five crops (bean, cucumber, squash, pepper, and tomato) are planted in the spring and in the fall. Since our ground observations began in the fall of 1972 and continued until the spring of 1974, only in calendar year 1973, when we made field observations both in spring and fall, could we compare the annual acreage estimate for these five crops with TCLRS estimates. Table 2 presents the acreage for the five spring and fall-planted crops during each of two fall and two spring growing seasons.

In both Tables 1 and 2, the standard error of the estimate, (s-x), (in acres) is given for each ground survey estimate. Calculation of s-x has the square root of the number of observations in the denominator. Consequently, for any crop when only one field was observed from among the 1,400 surveyed regularly, the standard error of the estimate equals the estimate, for example for cantaloupe, parsley, and squash for the 1972 crop (Table 1), and for bean and cucumber, for the spring 1974 crop (Table 2).

Table 1. Comparison of Texas Crops and Livestock Reporting Service (TCLRS) and ARS ground survey estimates and standard errors of the estimates ($s_{\bar{x}}$) of vegetable acreages in Hidalgo County in 1972 and 1973, and ground survey estimates of spring-planted vegetables in 1974.

	1972		1973		1974
	(Spring & Fall)	(Fall, only)	Spring & Fall		(Spring, only)
CROP	TCLRS estimates	Ground survey	TCLRS estimates	Ground survey	Ground survey
	Acres Harvested	Acres ± $s_{\bar{x}}$ Planted	Acres Harvested	Acres ± $s_{\bar{x}}$ Planted	Acres ± $s_{\bar{x}}$ Planted
Bean	-	2401±1589	-	1706±792	445±445
Beet	-	1399±791	-	945±570	Fall planted
Broccoli	1600	2555±1100	1100	1091±763	" "
Cabbage	9300	9698±2387	10700	13768±3513	" "
Carrot	11800	10546±3112	11200	10890±2260	" "
Cantaloupe	5400	796±796	5400	4581±1438	7645±1333
Cucumber	2800	992±651	2300	4346±2514	429±429
Lettuce	2300	3916±1425	1900	3145±1538	Fall planted
Mustard Greens	-	1864±862	-	540±399	" "
Turnip	-	1348±857	-	840±533	" "
Onion	10200	17667±3535	10600	13540±3422	" "
Parsley	-	187±187	-	861±487	" "
Peas	-		-	4869±2203	
Squash	-	441±441	-	940±448	0
Green Pepper	3200	1850±1116	2700	2716±1078	2118±880
Tomato	4200	4756±2354	2400	5025±1500	3178±1015
Cauliflower	100		500		
Sweet Corn	1400		300		
Honeydew melon	700		1000		
Spinach	100		50		
Watermelon	2400		1400		
Potato	1300		1400		
Other vegetables[a/]	3200		5650		
TOTALS	60000		58600		

[a/]Includes vegetables for processing, snap beans, beet, cucumber, tomato, and spinach.

Table 2. Acreages for fall of 1972 and 1973 and spring of 1973 and 1974 and standard errors of the estimate of five vegetables planted both spring and fall.

Crop	Fall '72	Spring '73	Fall '73	Spring '74
	Acres			
Bean	2401±1589	1004±670	702±439	445±445
Cucumber	992±651	604±378	3508±2929	429±429
Squash	441±441	234±234	706±235	0
Green Pepper	1850±1116	572±323	2144±938	2118±880
Tomato	4756±1130	2559±1130	2366±823	3178±1015

When the two estimates of acreages (Table 1) for 1973 are compared, it is evident that the estimates differ statistically only for cucumber (4,346 vs 2,300 acres) and tomato (5,025 vs 2,400 acres) with the ground survey estimates being higher than the TCLRS estimates for both crops. For crops planted only in the fall, the 1972 ground survey acreage estimated a greater acreage than the TCLRS for onion (17,667 vs 10,200 acres), and lettuce (3,916 vs 2,300 acres). The TCLRS and ground survey acreage estimates do not differ for any of the fall-planted crops in 1973. TCLRS estimates of 1974 crop acreages will not be published until 1975.

The ground survey estimates were consistently greater than the TCLRS estimates only for onion and tomato (Table 1) which may represent a positive bias in the particular fields sampled for these crops as compared with all the fields of the county. However, the particular sample of fields used in our ground survey satisfactorily represents most crops, except honeydew melon, watermelon, and potato. The ground survey does not contain many cultivated fields in the sandy western and northern sections of the county where cucurbits and potatoes are grown; therefore, estimates for crops grown principally on sandy soil are too low.

A few other circumstances could contribute differences to the two survey estimates. The TCLRS attempts to estimate only harvested acres, whereas the ground survey reflects planted acres. Experience of TCLRS has shown that about 5% of the planted acreage is abandoned prior to harvest because of poor stands, insect infestation, weeds, or other causes. During the periodic ground surveys, we collected data on fields that had reached harvest stage, on stand, and on percent crop and weed cover, but we did not specifically note abandoned fields and delete them from the estimates.

The TCLRS estimates are obtained by multiple frame sampling that uses questionnaires, telephone interviews, and personal visits with producers; a quarterly enumeration of shippers; and, estimates by county extension agents (5, p. 44). Variance of the estimates are calculated at the county level (personal letter from Lloyd Garrett, TCLRS, 5 August, 1974), but these data are not included in the annual TCLRS publications (4, 5).

Regular inspection of approximately 1,400 fields is a direct method of acquiring the crop information; the four interpenetrating samples used county-wide, and the four additional ones used in the southern part of the county for the fall and winter season served as replications that permitted calculating the standard error of the estimate.

Reliable estimates of crops planted to less than 5,000 acres are difficult to obtain by any sampling procedure. One reason is that they tend to be grown as specialty crops by a few growers or in a localized part of the county. If the particular growers or fields are not sampled, the county-wide estimates will be low. However, if over-sampled, the expansion factor (from sample to county estimate) will over-estimate the acreage. A large sampling error is associated with few observations, and a randomized sampling procedure conflicts with a nonrandom distribution of plantings.

Weather conditions, market outlook, water supply, and other factors influence the acreage of vegetables planted each season. The total acreage of vegetables in Hidalgo County from the TCLRS estimates of Table 1 was 60,000 in 1972 and 58,600 in 1973. For the 14 fall-planted vegetables of Table 1 and 2 (all crops listed except peas and cantaloupe), the ground survey total estimated acreage was 59,600 acres in 1972 and 55,000 acres in 1973. This decline could partly represent either farmer's satisfaction with good prices for cotton and grain sorghum in 1973, or rainy weather that interfered with planting. It could also reflect a trend to specialization and vertical integration. Either the high prices received by growers for onions in the spring of 1973 did not result in an increase in acreage planted in the spring of 1974, or the acreage planted for harvest in 1973 was based partly on advance knowledge that the supply of fresh onions from other areas would be low.

The acreages in Table 2 show that about the same acreage of pepper, tomato, and squash are planted in spring and fall. Bean and cucumber are planted predominantly in the fall, whereas corn is predominantly a spring crop. The acreage planted to beans has declined each season during the observation period.

A few crops exculded from Table 1 merit comment. Eggplant has virtually disappeared due to tobacco mosaic virus infection. One patch of eggplant (5.4 acres) was obsesrved in 1973 but none in 1972.Besides the green pepper, some Jalapeno and banana peppers are grown. The 1973 county estimates were 57 acres for Jalapeno and 137 acres for banana peppers. Southern peas (blackeye and purple hull) were planted in eight fields in the fall of 1973, and constituted an estimated 4,900 acres on a county-wide basis.

Table 3 gives the number of fields and their average size for two fall (1972 and 1973) and two spring (1973 and 1974) crop seasons. In the fall of 1972, the ground sample contained 170 vegetable fields planted to the 16 crops and 191 planted to 14 crops in the fall of 1973 (Table 3). In the spring of 1973 and 1974 the number of vegetable fields was 41 and 30, respectively. The field number as well as the acreage data show that the spring vegetable industry is only one-fourth to one-fifth that of the fall-winter industry.

The number of fields and acreage data show that onion, cabbage, and carrot are the major fall-winter vegetable crops, and that tomato and cantaloupe are the major spring crops. The most fields of any one crop were 66, for onion in the fall of 1973.

The average field sized did not vary much. It ranged from 21.0 to 23.6 acres per field for the different seasons. From 9 to 10% of the ground area in the sample was devoted to vegetables.

To determine when the fields should be surveyed and to minimize the number of future field visits, we listed the dates on which the maximum acreages of the various crops of Tables 1 and 3 were observed. We concluded that December and April ground surveys would reliably detect the acreage of all the important crops, although both optimum and earliest date varies with specific crops. For example, we concluded that acreage of fall-planted peppers can be estimated reliably by September 1. The acreages of the three very minor vegetable crops (bean, cucumber, and squash), are best estimated in October. Cabbage planting extends over a long time; in both years we observed some fields that had been harvested and the plants destroyed before the late fields were planted. The best date for surveying onion acreage is late January or early February. The spring-planted crops are all well established by mid-April. An observation in April can also detect late fields of cabbage, carrot, and onion, that might be missed in a December or even a January survey.

Since the inspection of the contents of a sampling of individual fields can yield acreage estimates for 25 or more crops (citrus, cotton, and sorghum included), the data can be provided at very low cost per acre or per commodity. We estimate that one surveyor could make the April and December field visits and profitably use the remainder of the year calculating the acreage estimates and providing the summaries and analyses desired by various commodity groups. The other large expense would be the vehicle mileage and depreciation. The calculations can be made on a desk calculator. About $20,000 per year should finance the service. Such a survey merits consideration, depending on its value to the particular commodity groups and the agricultural industry as a whole.

The most difficult aspect of a survey that includes a large number of fields is accurately determining the acreage of all the fields in the sample. The aerial photographs used in this study to identify and code the fields and segments were also useful as "road" maps to reach the fields and recognized them. The sample designed for this study could be made available if the industry desired it, and a number of the most difficult and tedious, but necessary, steps would already have been taken.

Table 3. Number and average field size for crops contained in ground survey of Hidalgo County in the fall of 1972 and 1973 and the spring of 1973 and 1974.

CROP	Fall '72		Spring '73		Fall '73		Spring '74	
	No. fields	Avg. size (Acres)	No. fields	Avg. size (Acres)	No. fields	Avg. size (Acres)	No. fields	Avg. size (Acres)
Bean	4	46.5	4	11.2	3	10.2	1	19.5
Beet	3	25.7	0	--	3	19.6	0	--
Broccoli	6	18.1	0	--	6	8.5	0	--
Cabbage	31	22.6	0	--	40	23.6	0	--
Carrot	39	20.3	0	--	28	19.0	0	--
Cantaloupe	1	34.9	8	30.1	0	--	12	30.4
Cucumber	3	70.3	3	8.8	6	27.3	3	9.4
Lettuce	14	19.1	0	--	7	23.5	0	--
Mustard Greens	4	13.2	0	--	2	19.6	0	--
Turnip	3	19.7	0	--	5	13.3	0	--
Onion	39	25.9	0	--	66	23.3	0	--
Parsley	1	8.2	0	--	3	18.4	0	--
Squash	1	38.6	1	10.2	3	10.3	0	--
Green Pepper	5	16.2	3	12.2	9	17.5	6	22.0
Tomato	13	26.2	21	19.5	10	18.7	9	17.9
Spinach	3	14.4	0	--	0	--	0	--
Watermelon	0	--	1	100.5	0	--	0	--
Totals	170	4010.3	41	869.7	191	4019.4	30	696.95
Avg.		23.59		21.21		21.04		23.23

ACKNOWLEDGEMENT

The authors thank Dr. Donald von Steen and Mr. Harold Huddleston for designing and drawing the statistical sample.

This study was supported in part by the National Aeronautics and Space Administration under Contract No. S-70251-AG, Task 3.

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Salinity and Nitrogen Fertilizer Interaction Effects on Micronutrient Content of Spinach

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ABSTRACT

The effect of four concomitant levels of soil salinity and nitrogen fertilizer on micronutrient absorption of greenhouse grown spinach (*Spinacia oleracea* L.) was studied on a calcareous soil. Plant growth mechanisms were apparently destroyed when soil salinity (EC_e) exceeded 7.1 mmhos/cm. Aluminum, Fe, Mn, and Zn concentrations increased sharply with the highest salinity (10.8 mmhos/cm) treatment. Increasing the nitrogen supply from 0 to 150 mg N/kg soil provided a dilution effect on all micronutrient uptake except Al, Fe, and Mo. However, only Fe, Mn, and Zn concentrations were significantly affected by the salinity x nitrogen fertilizer interaction. Judicial use of nitrogen fertilizer on saline soils possessing EC_e of 1.2 to 7.2 mmhos/cm induces a favorable salinity x nitrogen interaction as well as P/Zn and P/Fe concentration ratios to support spinach growth. Nitrogen fertilizer rates used did not produce a reported desirable Fe/Zn ratio above 1.5.

Micronutrient uptake is uniquely specific to most plant species and soil type on the moderately saline irrigated lands of South Texas. Moderately saline irrigation waters as well as high pH soils with readily available P supplies interfere with micronutrient uptake. Burleson et al. (3) observed P induced Zn deficiencies in both agronomic and vegetable crops grown on a fine sandy loam soil of the Lower Rio Grande Valley. Hipp (6) measured only a significant reduction in Mn content of carrots grown in a P fertilized clay soil of the same region. Neither placement nor rate of P fertilization significantly changed Zn and Fe content of carrot leaf tissue in the same experiment. Heilman et al. (5) observed a sorghum genotype specificity to Fe absorption in saline nutrient media. Excessive accumulations of Cu, Zn, and Mn interfered with Fe metabolism in some genotypes grown in calcareous solution cultures (2, 14). The effect of N fertilizer on quality of spinach chlorophyll has been demonstrated (4, 10, 12). Spinach is also a uniquely, fast growing, saline tolerant vegetable (1, 8). The effect of salinity and N stresses on micronutrient uptake of spinach remains unsolved. The purpose of this experiment was to study the interacting effects of salinity and n fertilization on micronutrient uptake by spinach.

MATERIALS AND METHODS

Spinach (var. Hybrid 424) was grown in a greenhouse at Weslaco, Texas on Brennan fine sandy loam (Typic Haplustalf) soil. This soil was chosen because of its low soluble-salt and total-N contents. Electrical conductivity of saturated soil extract (EC_e), sodium adsorption ratio (SAR) and saturation percentage (SP) values of this soil were 1.1 mmhos/cm, 0.60 and 25.5%, respectively. Cation exchange capacity was 11.4 meq/100 g. Soil pH was 7.7. Total N and $NaHCO_3$ extractable P (11) was considered medium and relatively high at 0.09% and 24 ppm, respectively. Analytical procedures used to measure soil properties were those outlined by the US Salinity Laboratory (13).

Average electrical conductivity (EC) of available irrigation water was 1.2 mmhos/cm or a salt concentration of 12.6 meq/liter. Synthetic irrigation water consisted of a misture of NaCl, $CaSO_4 \cdot 2H_2O$, $MgCl \cdot 6H^2O$, and KCl salts in a ratio of 7.0:3.5:2.0:0.1 meq/liter, respectively, for a basic solution of 1.2 mmhos/cm. Saline irrigation treatments developed were 1, 3, 6, and 9 times the basic synthetic solution (1.2, 3.6, 7.2, and 10.8 mmhos/cm) and are referred to as S_1, S_2, S_3, and S_4, respectively. Plant damping-off problems were experienced in the absence of N on the first attempt of this experiment. Approximately 3 liters of each treatment solution were applied in 250 ml increments daily for 12 days to 5 kg of soil. Soils were potted in 20 cm diameter pots with polyethylene liners. Soil equilibration was considered complete when the EC of leachates equalled that of the applied waters. Soils were then incubated at field capacity (15% moisture) for two weeks without further evaporation or drainage.

Spinach seed were planted during mid-January in the salinized soils and thinned to 12 plants per pot after emergence. The same treatment waters and drainage criteria were used after plant emergence. Reagent grade $Ca(NO_3)_2$ was applied in aqueous solution to develop N fertilization rates of 0, 50, 100, and 150 mg N/kg of soil, which are referred to as N_1, N_2, N_3, and N_4, respectively. Nitrogen was applied in three applications at 2-week intervals after emergence. Salinity and nitrogen treatments were factorially arranged in 4 x 4 design with 8 replicates giving a total of 128 pots. Plant leaf tissue was harvested two months after emergence. Tissue samples used for chemical analyses were washed with distilled water and freeze-dried. All samples were ground in a Wiley mill to pass a 40-mesh screen. Micronutrients were determined by spark emission spectroscopy as described by Jones and Warner (7).

RESULTS AND DISCUSSION

Relative effects of salinity and N fertilizer treatments on micronutrient concentrations in spinach tissue are given as statistical parameters in Table 1. None of the nutrients measured appears to be below critical levels (Table 2). Aluminum, Ba, and Sr are recognized as

Table 1. Statistical parameters of micronutrients.

Source	Micronutrient								
	Al	Ba	B	Cu	Fe	Mn	Mo	Sr	Zn
Salinity	**	**	**	*	**	**	**	**	**
Nitrogen	*	n.s.	*	**	**	**	**	**	**
Sal. x Nit.	n.s.	n.s.	n.s.	n.s.	*	**	n.s.	n.s.	**
LSD (P = .05)	65	1.7	7.6	3.5	20	36	0.6	39	33

** = 1% probability level, * = 5% probability level.

Table 2. Effect of salinity and nitrogen fertilizer on micronutrient content of spinach.

Nutrient	Salinity level mmhos/cm				Nitrogen level, Mg N/kg soil			
	1.2	3.6	7.2	10.8	0	50	100	150
	S_1	S_2	S_3	S_4	N_1	N_2	N_3	N_4
	ppm							
Al	384.0	277.0	288.0	407.0	290.0	331.0	352.0	372.0
Ba	12.2	11.8	8.5	7.8	15.2	9.2	8.2	7.5
B	58.0	37.0	26.0	24.0	56.0	34.0	30.0	24.0
Cu	12.0	14.0	12.0	14.0	20.0	13.0	11.0	8.0
Fe	191.0	147.0	133.0	185.0	147.0	172.0	167.0	170.0
Mn	238.0	209.0	191.0	202.0	303.0	208.0	181.0	148.0
Mo	3.0	3.4	3.6	4.3	3.4	3.5	3.7	3.6
Sn	207.0	245.0	228.0	221.0	273.0	222.0	210.0	196.0
Zn	156.0	197.0	179.0	228.0	290.0	183.0	160.0	128.0

nonessential for plant growth. Barium and B concentrations decreased whereas Mo increased with increasing salinity. All other micronutrient concentrations were erratic. Aluminum, Fe, Mn, and Zn absorption behavior with respect to salinity was particularly erratic. Plat growth (8) was considerably retarded at S_4 level and Al, Fe, Mn, and Zn concentrations increased sharply. Increasing N fertilizer apparently induced a dilution effect on all micronutrient concentrations except Al, Fe, and Mo. Both salinity and nitrogen main effects generally increased Al and decreased Ba and B. However, only Fe, Mn, and Zn concentrations were significantly affected by the salinity x nitrogen interaction. Differential genotype response of these elements has been previously related (3, 5, 6).

Zinc, Fe, and Cu were chosen to depict the three general types of surface responses among micronutrients. The convexity exhibited by Zn uptake at the S_2 treatment across all N levels suggest that salinity

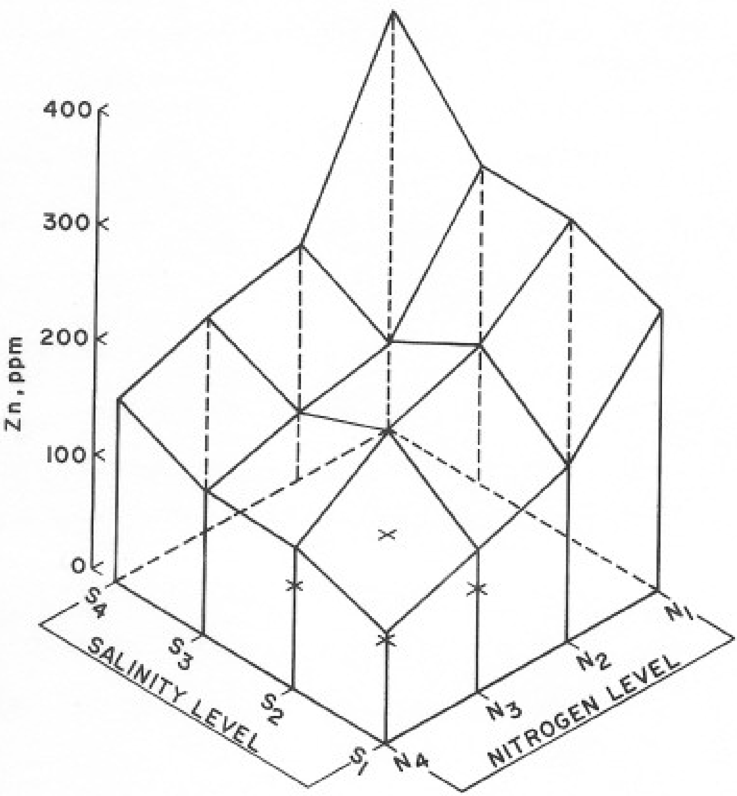

Fig. 1. Effect of salinity and nitrogen fertilizer on Zn concentration in spinach.

suppressed some type of antagonism (Fig. 1). However, the spinach plant appears Zn saturated at low N levels and high salinity levels. When Zn content of spinach tissue exceeded 200 ppm on these treatments, spinach growth was not adequate. Best growth appears to be related to Zn contents ranging from 100 to 175 ppm. Lingle et al. (9) reported Zn was one of the strongest interfering ions in decapitated plant studies and interfered with Fe uptake-transport by intact plants. A Sr response surface would be similar to that of Zn. Molybdenum was the only other micronutrient responding positively to salinity.

Iron response to the salinity x nitrogen interaction is considerably more complex (Fig. 2). Uptake trends tend to reverse with respect to N fertilizer on saline versus nonsaline treatments. Increasing salinity reduces Fe uptake at all levels of nitrogen fertilizer until spinach growth becomes severely limited by salinity. At the S_4 level, Fe content increased significantly over the S_2 and S_3 level at all N levels. A Ca-P imbalance in substrates with pH values near 7 to 8 may cause a reduction in Fe uptake and activity (2). However, Fe chlorosis was not observed nor indicated by measured chlorophyll (8). Aluminum and Mn uptake developed surface responses similar to that of Fe although they were not significant and are not presented.

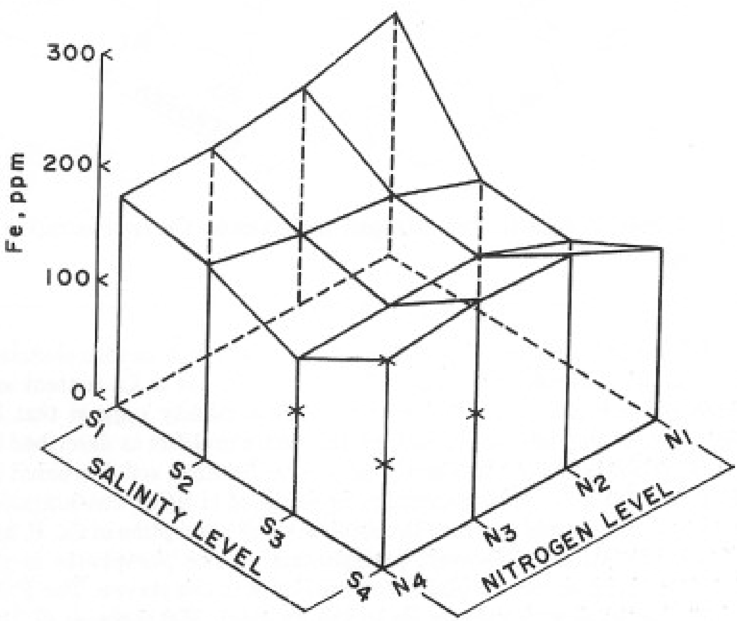

Fig. 2. Effect of salinity and nitrogen fertilizer on Fe concentration in spinach.

Copper content was mostly affected by increasing N supply (Fig. 3, Table 2). The N additions essentially decreased Cu linearly from 20 to 8 ppm at all levels of salinity and nitrogen. No interactive effects of salinity and nitrogen on Cu uptake were observed. Extremely high N levels could have conceivably affected Cu absorption in spinach. These data suggest that N fertilizer affects Cu uptake more antagonistically than that of Zn and P. The B response surface most resembled that of Cu. No salinity nitrogen interaction was observed since increasing both main effects reduced B concentration from approximately 57 ppm to 24 ppm.

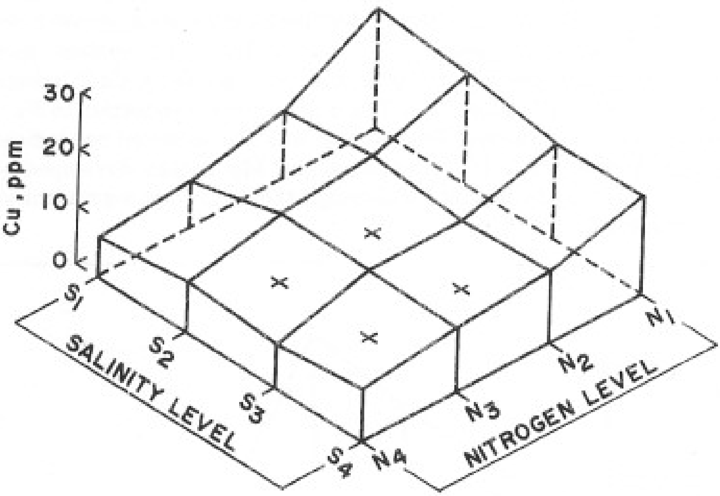

Fig. 3. Effect of salinity and nitrogen fertilizer on Cu concentration in spinach.

Indirect effects of the salinity x nitrogen interaction on micronutrient uptake may be observed in Tables 3 and 4. The increase in Ca content and the decrease in P and Fe content with increasing salinity suggest that Fe uptake was probably associated with a bicarbonate problem as described by Brown (2). Salinization of the slightly calcareous Brennan soil decreased its pH from near 7.8 to 6.7. The accompanying increase in HCO_3 concentration of the soil solution would increase the solubility and absorption of Ca, P, and to a lesser extent, Fe. However, precipitation of iron phosphates in the roots would result in low Fe and P concentration in the leaves. The P/Fe ratio also increased with salinity up to the S_3 level. Watanabe et al. (14) suggested that a P/Fe ratio > 60 would have a detrimental effect on yield. The P/Fe ratio appears excessively high in the absence of N fertilizer, and at the S_2 and S_3 salinity levels in the presence of N fertilizer. This may

Table 3. Effect of salinity and nitrogen fertilizer on macronutrient content of spinach.

Nutrient	Salinity level mmhos/cm				Nitrogen level, mg N/kg			
	1.2	3.6	7.2	10.8	0	50	100	150
	S_1	S_2	S_3	S_4	N_1	N_2	N_3	N_4
	----------------	----------------	----------------	----------------	%	----------------	----------------	----------------
Total N	2.4	3.2	3.5	3.8	2.3	2.7	3.8	4.4
Ca	1.12	1.46	1.42	1.44	1.64	1.40	1.24	1.16
Mg	0.70	1.19	1.36	1.50	0.70	1.13	1.45	1.48
P	1.08	1.11	1.06	0.89	2.32	0.79	0.58	0.45

Table 4. Effect of salinity and nitrogen fertilizer on nutrient concentration ratios of spinach.

Nutrient	Salinity level mmhos/cm				Nitrogen level mg N/kg			
	1.2	3.6	7.2	10.8	0	50	100	150
	S_1	S_2	S_3	S_4	N_1	N_2	N_3	N_4
	----------------	----------------	----------------	Concentration Ratio	----------------	----------------	----------------	----------------
Ca/P	1.01	1.31	1.34	1.62	0.71	1.77	2.14	2.58
P/Fe	56.00	76.00	80.00	48.00	158.00	46.00	35.00	26.00
P/Zn	69.00	56.00	59.00	39.00	80.00	43.00	36.00	35.00
P/Mn	45.00	53.00	56.00	44.00	77.00	38.00	32.00	30.00
Fe/Zn	1.22	0.75	0.74	0.81	0.51	0.94	1.04	1.33

account for the depression in Fe uptake at the S_2 and S_3 salinity levels (Fig. 2). The P/Mn ratio trends are very similar to those of P/Fe with respect of both salinity and N fertilizer (Table 4). The Mn response to the salinity x nitrogen interaction was highly significant (Table 1). However, the relationship of Mn to P is unknown. Brown (2) suggests the unavailability of Mn in neutral or alkaline soils may be due to the conversion of manganous to insoluble manganic oxides.

Salinity and nitrogen treatments used appear to exhibit no influence on phosphorus induced Zn deficiencies as reported by Burleson et al. (3). The P/Zn ratios decrease with both increasing salinity and N fertilization (Table 4). Increasing salinity and N fertilizer appears to accentuate the reported Fe-Zn uptake antagonism. Watanabe et al. (14) state that the addition of Fe was required to correct adverse effects on corn yields when the Fe/Zn ratio dropped below 1.5. All values (Table 4) for the Fe/Zn ratio are much lower than 1.5. Lowest Fe/Zn ratios occurred at the S_2 and S_3 salinity levels and in the absence of N fertilizer. However, spinach growth was best, but inversely, associated with Zn uptake.

Results of this study suggest that growth of spinach on moderately saline soils may be affected by micronutrient imbalances, especially the P/Fe and P/Zn concentration ratios.

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Quality of TexSel Greens
Brassica carinata A. Br., During Maturation

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ABSTRACT

TexSel greens, *Brassica carinata* A. Br., from two plantings were harvested weekly during maturation. Total yield per ha was determined, and total solids, ash, Ca, Fe, K, P, Na, protein, and NO_3-N of the whole plants were analyzed weekly. Total yield and Ca increased in one planting and decreased in the other. Ash content was a little greater in young than in old plants of both plantings. Fe fluctuated in both plantings, and K did not change in either. P, Na, and protein increased or fluctuated slightly in one planting and remained constant in the other. NO_3-N decreased in one planting and did not change in the other. The study indicates that TexSel greens are similar in growth characteristics and quality factors to those reported in the literature for other green leafy vegetables. The greens could be harvested over a period of about 3 weeks in the South Texas Area for canning or freezing without changes in quality.

TexSel Greens, *Brassica carinata* A. Br., is a recently released green leafy vegetable suitable for production in South Texas (7). Seed of TexSel was originally received in 1957 as P.I. 243913 from Ethiopia. The crop, introduced as a possible source of oil from the seed, was first grown in Texas in the winter season of 1966-1967 in the New Crops Program of the Texas A & M Univ. Agr. Res. Ext. Center, Weslaco, Texas. Stephens, et al. (14) reported that the flavor of the cooked greens was somewhat milder than that of collard greens and without the pungency associated with cultivars of mustard greens. These investigators compared the quality of young plants with that of plants just beginning to flower and found differences in acidity, °Brix, ascorbic acid, oxalic acid, and protein, which were attributed to differences in maturity of the plants.

Brown, et al. (3) reported that the stage of maturity of the plants affected protein, xanthophyll and carotene contents of the heat-precipitated coagulum from juice pressed from the whole plants.

We proposed to determine whether yield, mineral compositions, and quality factors vary with plant maturity.

MATERIALS AND METHODS

Seeds were planted in 30.5 m double rows, 30 cm apart, with 60 cm between double rows in 0.4 ha blocks on 3 and 30 October 1969 at the Texas

A & M Univ. Agr. Res. and Ext. Center, Weslaco, Texas. Plants were harvested from the first planting starting on 1 December and weekly for 5 weeks. Harvest was initiated on the second planting on 6 January and continued weekly for 7 weeks. The plants were cut about 5 cm above the ground to simulate machine harvest, and each harvest period, four samples, each consisting of 3 m of a duble row, were randomly selected from the 0.4 ha planting. The dead and diseased leaves were removed, and the plants were tumbled and air-cleaned without added moisture.

Total solids, ash and protein (Kjeldahl Nx6.25) were determined by A.O.A.C. procedures (1).

Calcium, Fe, K, and Na were determined with a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer (Use of a company and/or product named by the Department does not imply approval or recommendaions of the product to the exculsion of others which may also be suitable.) by the procedure described by the manufacturer of the instrument (10). Phosphorus was determined as outlined by Chapman and Pratt (4), and NO_3-N by the procedure of Kamm, et al. (9).

RESULTS AND DISCUSSION

Yield per acre differed greatly between plants harvested from the first and second plantings. The first harvest of the first planting, 59 days from planting, yielded 36.1 metric tons (MT)/ha, or 16.1 tons/acre (Table 1), while the first harvest from the second planting, 66 days from planting, yielded only 10.3 MT/ha, or 4.6 tons/acre (Table 2). Yield data of Cowley, et al. (7) for four seasons, 1967 to 1970, show a minimum of 14.5 tons/acre in 1969 and a maximum of 18.5 tons/acre in 1968. Stephens, et al. (14) reported a total yield of about 20 tons/acre. A 10-day period of rainy weather during the last week in November and first week in December seemed to adversely affect both plantings. Some of the lower leaves of plants harvested 22 and 29 December of the first planting had decayed and dropped from the plants, causing the yield to decline from 39.0 to 30.7 MT/ha. The young plants of the second planting seemed stunted and dropped most of their lower leaves, and did not grow as rapidly as plants of the first planting. Stephens, et al. (14) reported that TexSel greens exhibit a field resistance to downy mildew but did not to powdery mildew. It is not known for sure what caused the plants of the second planting to be stunted. The excess moisture and possible disease could have been factors causing the plants to grow slowly, reducing total yield. Whether the plants were infected by downy or powdery mildew was not determined by pathological examination.

Total solids (TS) of plants harvested from the first planting were lower than those of plants from the second planting (Tables 1 and 2).

Table 1. Analyses of first planting of TexSel Greens[z/y/]

Date harvested	Yield MT/ha	Total solids %	Ash[x] %	Ca[x] %	Fe[x] %	K[x] %	P[x] %	Na[x] %	Protein[x] %	NO_3-N[x]
Dec. 1	36.1	6.7a	23.3b	2.45ab	.021abc	3.93a	.32a	1.47a	27.1a	1.28c
Dec. 8	41.5	7.6a	23.5b	2.40a	.026c	3.90a	.35a	1.75a	27.8a	1.17b
Dec. 15	39.0	8.8b	22.4ab	2.79c	.019ab	3.85a	.34a	1.37a	28.4a	1.08b
Dec. 22	35.0	9.4b	21.0a	2.76bc	.016a	3.35a	.33a	1.36a	26.5a	0.85a
Dec. 29	30.7	9.7b	21.7a	2.81c	.024bc	3.56a	.36a	1.31a	27.3a	0.85a

z/The data represent the mean of duplicate determinations of 4 replications.

y/Means within columns followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (13).

x/Dry weight basis.

Table 2. Analyses of second planting of TexSel Greens[x/y/]

Date harvested	Yield MT/ha	Total solids %	Ash[x] %	Ca[x] %	Fe[x] %	K[x] %	P[x] %	Na[x] %	Protein[x] %	NO_3-N[x]
Jan. 6	10.3ab	11.0bcd	22.0b	3.17c	.021d	3.62a	.39a	0.94ab	-	0.78a
Jan. 12	9.2a	12.5c	19.4a	2.77b	.014a	3.29a	.37a	0.77a	24.0a	0.60a
Jan. 19	12.6bc	11.6d	18.3a	2.49a	.016ab	3.37a	.04a	0.81a	28.5ab	0.66a
Jan. 26	13.5bcd	10.1a	18.8a	2.45a	.017bc	3.80a	.44b	0.96abc	31.1ab	0.63a
Feb. 2	15.2cde	10.3abc	19.0a	2.31a	.029e	3.67a	.45b	1.14bc	29.3ab	0.69a
Feb. 9	24.2f	9.8a	18.4a	1.36a	.017bc	3.47a	.38a	1.24c	30.5ab	0.79a
Feb. 16	28.5g	10.2ab	19.1a	2.55a	.019cd	3.38a	.40a	1.11bc	31.7b	0.59a

z/The data represent the mean of duplicate determinations of 4 replications.

y/Means within columns followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (13).

x/Dry weight basis.

Plants of the first planting increased in TS from 6.7 to 9.7%, as the plants matured. In the second planting, TS of plants harvested on different dates differed statistically but not uniformly as the plants matured. Zink (17) reported that a fluctuation in the per cent dry matter of spinach appeared to be related to the irrigation schedule. Reder (12) found that time of day of the harvest significantly affected the dry matter of turnip greens. Similar conditions might have caused the fluctuation of TS in plants of the second planting, as the plants matured.

The ash content was slightly greater for plants of the first planting than for the second. The ash values, 23.3 and 23.5%, of the young plants of the first planting harvested 1 and 8 December and the ash value, 22.0%, of the young plants of the second planting harvested 6 January were a little higher than those of the older plants in the respective planting.

As the plants matured, the percentage Ca of plants from the first planting increased slightly from 2.45 to 2.81, whereas that of plants from the second planting decreased from 3.17 to 2.55. Zink (17) reported that Ca concentrations of spinach were fairly constant in one field plot but tended to increase in another as the plants approached maturity.

Fe content varied from .016 to .026% for plants of the first planting and .014 to .029% for plants of the second planting, but the differences could not be attributed to the maturity. The ranges of the Fe content were similar for both plantings.

K for both plantings or P for the 1st planting did not differ statistically with harvest date. P for the second planting, however, did differ slightly with harvest date. K ranged from 3.35 to 3.93% for the first planting and 3.29 to 3.80% for the second, and P fluctuated from .32 to .36% for the first planting and .37 to .45% for the second.

The decreases in Ca, Fe, K and P between the harvests of 2 and 9 February probably reflected the dilution of these elements within the plant. The plants had been growing slowly up to the 2 February harvest. The increase in yield from 15.2 to 24.2 MT/ha and a corresponding decrease in TS from 10.3 to 9.8% indicate the plants increased rapidly in size and in moisture content.

The Na content of plants of the first planting fluctuated from 1.31 to 1.75% with harvest period, but the concentrations were not statistically significant. However, in plants of the second planting, Na concentrations differed statistically and increased from 0.94 to 1.11% as the plants matured. Zink (17) reported that the Na content of spinach fluctuated during growth but tended to increase with plant maturity.

Protein content of plants of the first planting was rather constant during growth and varied from 26.5 to 28.4%. Plants of the second planting increased in protein from 24.0% at the second harvest to 31.7% at the last harvest. The protein content of these plantings of TexSel greens was about the same as the protein contents reported by Stephens, et al., 27.0 to 31.3% (14), Brown, et al., 20.1 to 27.8% (3), and Cowley, et al., 30% (7).

As the plants matured NO_3-N decreased from 1.28 to 0.85% in plants of the first planting but did not change significantly in those of the second planting. The accumulation of NO_3-N in the edible portion of plants has caused NO_3 poisoning (methemoglobinemia) in ruminant animals and in humans, particularly infants (8). The levels of NO_3-N in plants of the first and second planting of TexSel greens were, respectively slightly greater than and about the same as the levels in spinach reported by Cantliffe (6). He found that spinach, cultivars Virginia Savoy and Northland contained 0.82 and 0.63% NO_3-N respectively after fertilization with 200 mg N/kg soil. Temperature (6), photoperiod and light duration (5), storage temperature (11) and nitrogen fertilization (2) affect the NO_3-N content of spinach. Thus, one or more of these factors could have caused the slightly higher NO_3-N content of TexSel greens in the first planting.

These results suggest that the yield and quality characteristics of TexSel greens are similar to those reported in the literature (15, 16) for spinach and other maturing green leafy vegetables.

Of importance to potential growers of this crop is the finding that plants harvested before the approximate dates of 15 December for the first planting and 26 January for the second planting were ideal for canning or freezing. At this stage of growth the central stalk which had started to elongate had not developed fiber. A processor in the South Texas area would have as long as 3 weeks, and possible a little longer, to cut the greens for canning or freezing before fiber development. After these dates for their respective plantings, stalks developed fiber and may not have been suitable for canning or freezing.

ACKNOWLEDGEMENT

The authors thank Mr. W. R. Cowley, Director of Research, Texas A & M University Agricultural Research and Extension Center at Weslaco, Texas for supplying the TexSel greens *Brassica carinata* A. Br. for this study.

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Fall Production of Oil Type Sunflower in the Lower Rio Grande Valley of South Texas

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ABSTRACT

An experiment was conducted to determine the yield, seed oil characteristics, and pest hazards of fall (late summer planted) sunflower production. Seed yields ranged from 944 kg/ha (experimental Site No. 2 not protected from insects, nematodes, and birds) to 1,796 kg/ha (protected Site No. 1). The mean oil percent for all cultivars of both sites was 43.1%. The oil of all cultivars was high in linoleic and low in oleic fatty acids. The sunflower head moth, birds, and nematodes reduced yields and are potential hazards for a sunflower industry in the Lower Rio Grande Valley of South Texas.

Sunflowers, *Helianthus annus* (L.), have been successfully grown in many European countries, and more recently (1960's) in North Dakota and Minnesota, and most recently in Texas, as an oilseed crop (7, 8, 10). Hybrids were first planted commercially in Texas, in 1974. The sunflower seed is a new protein and oil source for human consumption, and the defatted meal is an excellent high protein supplement for livestock feeds (9). Because of its nutritional and feed value, it may be fortunate and very timely that development of sunflower hybrids coincided with the current decrease in cotton production in Texas, thus providing another cash crop. One advantage of growing sunflowers in cotton-producing regions is the presence of cotton oil mills which have surplus crushing capacities suitable for sunflower seed without major mill modifications.

Because sunflowers have a large latitude in planting and harvesting dates, double cropping in areas like the Lower Rio Grande Valley of South Texas (LRGV) is possible. Throughout Texas, because of conditions like drought or hail which either delay or destroy crop plantings, the need for an alternate short season crop is critical.

Sunflowers as compared with other short season crops have reduced fertilizer, water, and energy requirements which are appealing advantages.

Sunflower seed production was first attempted in the LRGV during the mid-1960's. Yields of open pollinated sunflower cultivars ranged from

832 to 1,821 kg/ha. However, these yields were not considered economical because of the low seed price, and the destructiveness of the sunflower moth, *Homoeosoma electellum* (Hulst). Several factors have contributed to sunflowers becoming economical in recent years. Hybrids have been developed with shorter blooming and maturity periods than open pollinated cultivars, which allows controlling sunflower head moth and quicker harvesting. The international shortage of eatable oils has also created additional markets for sunflower oil and by-products.

There is very little research on the cultural and management requirements for the production of hybrid sunflowers in the LRGV or South Texas region. Therefore, the objectives of this study were: (1) to determine the yield potential of sunflower planted in late summer to mature in November or December in the LRGV, (2) to determine what effect nematodes, insects, and other potential pests, like birds, might have on seed production, and (3) to determine the effects of cool temperatures on oil quantity and quality during seed maturation.

METHODS AND MATERIALS

One open pollinated variety (Peredovik-66), designated as Cultivar 1, and three hybrid sunflower strains (cms 89 x RHA 272, cms HA 60 x RHA 265, and cms HA 89 x RHA 265), designated as Cultivars 2, 3, and 4, respectively, were planted at two locations in the LRGV.

U. S. Department of Agriculture Research Farm Location [Site No. 1]. The four sunflower cultivars were planted in dry soil on 29 August 1974, and irrigated for germination. A randomized complete block with five replications was used. The soil type at the experimental site was Hidalgo fine sandy loam. The plots consisted of eight rows 9.1 m (30 ft) long. The plots were thinned to a plant population of approximately 53,000 plants/ha (22,000 plants/acre) with 18- to 23-cm (7- to 9-in) intervals between plants within the row. When the plants were approximately 25.4 cm (10 inches) tall, they were sidedressed with 67 kg/ha (60 lb/acre) of nitrogen as urea. From the two center rows 8 m (25 ft) were harvested for yield. Heads in the yield rows were also covered with paper bags immediately after initial bloom for a comparative evaluation of bird damage. The plots were sprayed three times on a 7-day schedule beginning at first bloom with methyl parathion (1.12 kg/ha, 1 lb/acre) for sunflower moth control.

The sunflowers were harvested in mid-December (9-17 December).

Weslaco Research Center [Site No. 2]. Planting and cultural practices were similar to those for Site No. 1. The plot consisted of four rows on 102-cm (40-inch) centers, 15 m (50 ft) long. This experimental design was a randomized complete block design with three replications. Yields were obtained by multiplying the average dry weight of seeds per head, by the head number per 8 m (25 ft) of row.

The Site No. 2 plots were on an area with a known population of the reniform *Rotylenchulus reniformis* Linford and Oliveira, and root-knot, *Meloidogyne incognita* (Kofoid and White) and Chitwood, nematodes. Soil samples were collected 20 September, 30 October, and 19 December 1974 to determine the effect of the reniform population on sunflower yield. A composite soil sample (5 sub-samples/sample) was collected from each plot with a nursery spade at a depth of approximately 15 cm (6 inches). Each sample was mixed and 100 g (0.22 lb) of soil was placed on a Baermann funnel. After 48 hr, the nematodes were extracted and counted with the aid of a stereomicroscope. Sunflower roots from 6 plants/plot were indexed for root-knot nematode galling percentage on 20 September and 19 December 1974.

Fourteen days after planting, the sunflowers were sidedressed with 34 kg/ha (30 lb/acre) of nitrogen as urea. Plots at this site were not sprayed for insects or protected from bird damage.

Entomological Aspects. From 1 October to harvest, insect populations at both sites were monitored weekly. During these inspections, all plants in a 2-m (6.5-ft) row sample of the first four replications Site No. 1, and the first three replications Site No. 2, were carefully examined. No attempts were made to sample for soil-inhabiting insects.

Oil Analyses. Sunflower seed were analyzed for total oil content by a modification of AOCS Method Ab 3-49 (6). Gas chromatographic analyses of the fatty acid methyl esters (3) were made using a Tracor MT 220 gas liquid chromatograph equipped with an Infotronics Model CRS-101 digital integrator. A 3.05 m (10 ft) x 1.27 cm (½ inch) stainless steel column packed with 10% EGSS-X on 100/120 mesh Gas Chrom P was used for the analyses and the column was operated at 190 C.

RESULTS AND DISCUSSION

The yields for the two locations were different (Table 1). The mean yield for all cultivars at Site No. 1 was 1,617 kg/ha (1,441 lb/acre) as compared with 1,070 kg/ha (953 lb/acre) at Site No. 2. This difference is attributed to the high level of management (which included a moth spray program, bird protection, and nematode-free soil) at Site No. 1. If the mean yield of 1,070 kg/ha (953 lb/acre) from Site No. 2 is comparable with the expected lower limit for fall production under adverse insect and soil conditions, then fall sunflower production in the LRGV seems profitable.

There were no significant yield differences among cultivars for either location. However, the hybrid cultivars (No. 2, 3, and 4) yields were higher than the open pollinated Cultivar 1 (Peredovik-66). The high yield of 1,796 kg/ha (1,600 lb/acre) for cms 89 x RHA 272 was considered good for late summer planted sunflower.

Table 1. Total seed yield at two locations, U. S. Department of Agriculture Research Farm (Site No. 1), and Weslaco Research Center (Site No. 2), for four sunflower cultivars; Peredovik-66 (#1), cms 89 x RHA 272 (#2), cms HA 60 x RHA 265 (#3), and cms HA 89 x RHA 265 (#4).

Cultivars	Site No. 1[1]	Site No. 2[2]
	----------kg/ha[3]----------	
1	1,443a[4]	1,150a
2	1,796a	1,073a
3	1,640a	1,112a
4	1,588a	944a
Overall Mean	1,617	1,070

1 Insects were controlled by spraying; bird protection was provided; and and plots were nematode free.

2 No insect or bird control measures were applied. Plots were infested with *Rotylenchulus reniformis* and *Meloidogyne sp.* nematodes.

3 Multiply by 0.891 to obtain lb/acre.

4 Numbers followed by the same letter within each column are not significantly different at P = .05 level as determined by Duncan's Multiple Range Test.

Seed weight per head, head diameter, and plant height influenced harvesting and oil yields of four sunflower cultivars on Site No. 1 (Table 2). There was a significant difference in seed weight per head among cultivars. Seed weight per head ranged from 77 g (0.17 lb) for Cultivars 1 and 2 to 64 g (0.14 lb) for Cultivar 3. There was no significant difference in head diameter among cultivars. The mean head diameter for all cultivars was 16.7 cm (6.6 inches). There was a significant difference in plant heights among the cultivars. Plant heights in descending order were 193.5, 181.8, 171.8, and 165.2 cm (76.1, 71.5, 67.7, and 65.0 inches) for Cultivars 4, 3, 1, and 2, respectively. The plant heights were normal for the cultivars, and their height would not pose any difficulty for harvesting.

Table 2. Average seed weights, head diameters, and plant heights for four sunflower cultivars (Site No. 1); Peredovik-66 (#1), cms 89 x RHA 272 (#2), cms HA 60 x RHA 265 (#3), and cms HA 89 x RHA 265 (#4).

Cultivars	Seed weights/head[1]	Head diameters[2]	Plant heights[3]
	g	cm[4]	
1	77a[5]	16.8a	171.8c
2	77a	16.8a	165.2d
3	64b	16.2a	181.8b
4	68ab	16.8a	193.5a
Mean	72	16.7	178.1

1 Mean head weights of all plants within the yield rows (dry weight).

2 Mean head diameters of all plants within the yield rows.

3 Plant heights at harvest.

4 Multiply by 0.393 to obtain head diameters and plant heights in inches.

5 Numbers followed by the same letter within each column are not significantly different at P = .05 level as determined by Duncan's Multiple Range Test.

The relationship between head diameter and yield as determined by correlation coefficients, which were significant, ranged from 0.72 to 0.82 for the four cultivars. Since this relationship is important, it may be used for estimating yields from losses because of seed shattering, insect damage, or bird damage. An overall equation may be used for estimating yields of most sunflower cultivars ($y = -38.41 + 4.76x$), where y is the estimated head yield and x is the head diameter.

The percent oil and fatty acid composition of the sunflowers is presented in Table 3. The oil compositions for Site No. 1 ranged from 35.8% (cms HA 60 x RHA 265) to a high of 50.5% (cms HA 89 x RHA 265); Peredovik-66, the open pollinated variety, had an oil content of 41.3%. The mean percent oil for all cultivars at both locations was 43.1%.

Table 3. Mean analysis of seed (Sites No. 1 and 2) for four sunflower cultivars; Peredovik-66 (#1), cms 89 x RHA 272 (#2), cms HA 60 x RHA 265 (#3), and cms HA 89 x RHA 265 (#4).

Cultivars	Mean oil[1]	Mean Fatty Acid Composition for Sites 1 and 2					
		Palmitic	Stearic	Oleic	Linoleic	Arachidic	Benhenic
				%			
1	42.9	5.6	5.1	17.2	71.2	0.5	0.6
2	48.4	5.9	4.1	14.1	75.1	0.5	0.5
3	34.0	5.2	5.8	18.4	69.8	0.5	0.6
4	47.0	5.9	4.7	13.5	75.0	0.5	0.5
Mean	43.1	5.7	4.9	15.8	72.8	0.5	0.6

[1]Dry weight basis.

The type of fatty acid is one of sunflowers' most important features since it determines the oil's potential use. All cultivars were high in linoleic fatty acid. The overall mean linoleic fatty acid content was 72.8%, whereas, the overall mean for oleic fatty acid content was 15.8%. The oleic content of

Cultivar 3 did reach 20.4% at Site No. 2, and the mean for both sites was 18.4%. Seed development under cool temperatures (November and December) apparently changes the metabolism of the plant, resulting in high lineoleic fatty acid content (1, 2, 5). Sunflower oil with high linoleic acid and high ratio of polyunsaturated to saturated fatty acids is very desirable as an edible oil in light of evidence linking saturated fats to high blood cholesterol and incidence of heart disease. Thus, such oils have great marketing potential for use in salad oils and in premium-grade margarine. Data from sunflower plantings in the Cotton Belt suggested that to produce commercial type frying oils (high in oleic fatty acid), sunflowers should be planted in the spring or early summer and mature during the warmer part of the LRGV growing season (2, 5). However, this observation is speculation and additional research data are required to determine how temperatures during seed development affect the type of fatty acid formed.

Nematode counts and root-knot index data (Table 4) show that the reniform and root-knot nematodes increased from a low initial count to a final high count and root-knot index. No significant difference was noted in nematode injury due to cultivar. Under the conditions of this test, yield reduction attributed to nematode injury was not distinguished from insect damage to the seed head. Plants at Site No. 2 were smaller and showed uneven growth which was attributed to nematode injury. Further research is needed with experiments designed to investigate nematode effects on the growth of sunflowers in the LRGV.

Table 4. Soil counts and root index estimates of nematode infestation of four sunflower cultivars (Site No. 2); Peredovik-66 (#1), cms 89 x RHA 272 (#2), cms HA 60 x RHA 265 (#3), and cms HA 89 x RHA 265 (#4).

	Cultivars			
	#1	#2	#3	#4
	Soil counts/100 g			
Rotylenchulus reniformis				
September 20, 1974	720	193	180	413
October 30, 1974	1,573	2,129	1,167	1,716
December 19, 1974	2,990	2,310	3,710	3,080
	Root index[1]			
Meloidogyne sp.				
September 20, 1974	2.6	2.7	2.6	2.3
December 17, 1974	5.0	4.6	5.0	4.9

[1] Root index: 1 = no galling
2 = 1 to 24% galling
3 = 24 to 49% galling
4 = 50 to 74% galling
5 = 75 to 100% galling

Table 5. Field counts of insect pests of sunflowers at Sites No. 1 and 2 of four cultivars; Peredovik-66 (#1), cms 89 x RHA 272 (#2), cms HA 60 x RHA 265 (#3), and cms HA 89 x RHA 265 (#4).

Insects and date	Cultivars				
	#1	#2	#3	#4	Mean
	Avg. no./ha[1]				
	Site 1				
Cabbage loopers (larvae)[2,3]					
Oct 1 to Oct 15	10,502	11,120	5,560	6,178	8,340
Oct 12 to Nov 1	12,355	12,355	8,649	11,120	11,120
Suleima helianthana (larvae)					
Oct 15 to Nov 1	1,236	1,236	0	1,236	927
Nov 1 to Nov 15	0	0	0	0	0
Nov 15 to Dec 1	0	0	0	0	0
Sunflower moth (infected heads)					
Nov 1 to Nov 15	0	618	0	0	154
Nov 15 to Dec 1	1,236	1,236	0	0	618
	Site 2				
Cabbage loopers (larvae)[2,4,5]					
Oct 1 to Oct 15	3,294	4,942	4,114	3,294	3,911
Oct 15 to Nov 1	6,583	4,937	4,937	3,294	4,938
Suleima helianthana (larvae)					
Oct 1 to Oct 15	6,583	1,646	1,646	0	2,469
Oct 15 to Nov 1	2,464	1,646	3,294	5,767	3,293
Nov 1 to Nov 15	1,648	3,296	3,296	3,296	2,884
Sunflower moth (infected heads)					
Oct 15 to Nov 1	1,648	0	0	1,648	824
Nov 1 to Nov 15	13,183	4,119	3,294	1,648	5,561
Nov 15 to Dec 1	16,482	9,889	6,593	16,482	12,362

1 Multiply by 0.405 to obtain avg. no./acre.

2 Cabbage loopers counts were discontinued after Nov. 1 since the large rapidly growing plants were not very susceptible to injury from the pest after that time.

3 Beginning with 50 to 75% bloom, U. S. Department of Agriculture Research Farm (Site No. 1) was sprayed three times on a 7-day schedule with 1 lb/acre rate of methyl parathion for sunflower moth control.

4 Cultivars were not treated with insecticide.

5 Results are expressed as the average of weekly examination of one sample per replicate, three replicates per cultivar.

The insects that were identified in the plots of both sides and the extent of damage are presented in Table 5. The sunflower plants in all plots experienced some damage from cabbage looper, *Trichoplusia ni* (Hbn); however, the leaf feeding of this pest probably had little if any effect on the seed yields of this rapidly growing crop. About mid-October a lepidopteran pest, *Suleima helianthana* (Riley), was found in the experimental plots of Site No. 2. The larvae of this pest usually entered the stem in the leaf axil just below the head where they caused considerable damage to the vascular system. Such damage resulted in small heads with undeveloped seeds or, in some cases, complete loss of head. All cultivars evaluated seemed about equally susceptible to this pest. Soon after the first open heads appeared, larvae of the sunflower moth were detected. These larvae infested the heads causing extensive damage to the maturing seed. Cultivars 1 and 2 which bloomed first (Peredovik-66, and to a lesser extent, cms 89 x RHA 272) seemed to have the most severe infestations of this pest; however, by 1 December all cultivars at Site No. 2 were about equal in terms of number of heads infested. Sunflower moth infestations at Site No. 1 were quite low, presumably because of the three insecticide applications (beginning at 25 to 75% bloom) which were made to suppress this pest.

Birds were another pest problem which could seriously reduce yields or totally destroy the crop in a short time period. The planting at Site No. 2 (in city limits) was destroyed by sparrows and many seed heads were either eaten or shattered. These plants were damaged near the optional harvest date when the seed coat reached full maturity. Sunflowers in the LRGV should not be planted near known bird populations. If the spring planting date is integrated with the expected harvest or maturity of grain sorghum, this would effectively disperse the bird population.

CONCLUSIONS

The growth of late August planted sunflowers at two locations was excellent. The late summer planting dates took advantage of the increased rainfall frequency which commonly occurs in late August and September (4).

Yields with good insect management (Site No. 1) averaged 1,617 kg/ha (1,440 lb/ac) for all cultivars. From a comparison of Sites No. 1 and 2 evidently both the sunflower moth and nematodes reduced yields. The sunflower moth was effectively controlled at Site No. 1 with three spray applications of methyl parathion (1.12 kg/ha, 1 lb/acre).

Sunflowers harvested in December were high in linoleic fatty acid (overall mean 73.3%). Oil contents were good and ranged from 35.8% to 50.5%.

Sunflowers may be planted in late summer in the LRGV for winter harvesting. The day neutral short season aspects of the sunflower plants make it a definite possibility for use in either single or double cropping systems in the LRGV.

Yields of summer planted sunflowers may be further increased by planting in late July or early August, as compared with our late planting date of this experiment.

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Cotton Leaf Air Volume and Chlorophyll Concentration Affect Reflectance of Visible Light

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ABSTRACT

The premise was tested that visible light (400 to 700 nm) reflectance from cotton (*Gossypium hirsutum* L.) leaf cell wall-air interfaces, represented by internal air volume (IAV), interacts with reflectance associated with leaf chlorophyll (chl) concentration. Reflectance was spectrophotometrically measured on noninfiltrated and water-infiltrated leaves, chl was assayed on noninfiltrated tissue, and weight increase with infiltration represented IAV.

Water-infiltrated leaves had 5.4 and 2.3% less reflectance (significant $P = 0.01$) than noninfiltrated leaves at the 550 (green reflectance peak) and 680 - (chl absorption band) nm wavelengths, respectively. Reflectance was linearly correlated with both IAV/cm^2 of leaf area ($r = -0.501^*$ at 550 nm; $r = -0.636^{**}$ at 680 nm) and chl concentration ($r = -0.737^{**}$ at 550 nm; $r = -0.811^{**}$ at 680 nm). Data for the 680-nm wavelength were used for an interaction study. Internal air volume interacted with chl concentration to affect reflectance, but chlorophyll concentration had 5.6 times more effect. Results help explain the light reflectance from crop leaves of different ages and chlorophyll concentrations.

Cell wall-intercellular air space interfaces in leaf mesophylls are associated with near-infrared light reflectance over the 750 to 1350-nm wavelength interval (2, 6, 7, 10, 11) and with visible light reflectance over the 500 to 750-nm wavelength interval (3, 6, 11) because light is scattered in passing from hydrated cell walls with a refractive index of 1.425 (3) to intercellular air with a refractive index of approximately 1.0. This can be easily demonstrated by replacing air in leaves by vacuum infiltration with media of higher refractive indices, which reduce light reflectance by partly eliminating cell wall-air interfaces (3, 11).

Although reflectance measurements on leaves can be used, for example, to follow changes in chlorophyll (chl) concentration (1) or to quickly estimate the N status of sweet pepper plants (9), correlations of leaf reflectance with chl concentration are sometimes poor (H. W. Gausman and J. R. Thomas, unpublished data). Mature leaves with many cell wall-air interfaces have a better correlation of chl concentration with reflectance than do young leaves with fewer interfaces; dorsiventral leaves (many interfaces) have higher reflectance than isolateral leaves (fewer interfaces) at the same chl concentration.

In cotton leaves, the number of cell wall-air interfaces was associated with internal air volume (IAV); young leaves have fewer intercellular air spaces (less IAV; than mature leaves (2). In this study, therefore, IAV is used to represent cell wall-air interfaces.

An increase in IAV in a noninfiltrated cotton leaf would increase reflectance, whereas an increase in chl concentration would decrease reflectance because of increased light absorptance. Theoretically, therefore, a leaf with high IAV would have more reflectance than a leaf with lower IAV, assuming that the two leaves had the same chl concentration.

This study tests the hypothesis that reflectance from cotton (*Gossypium hirsutum* L.) leaf cell wall-air interfaces, represented by IAV, interacts with reflectance associated with leaf chl concentration.

MATERIALS AND METHODS

Twenty cotton leaves (cultivar Stoneville 213) of various ages, ranging in size from 33.6 to 197.8 cm^2 (mean 102.8 ± standard deviation of 46.4 cm^2), were selected from several field-grown plants. Leaves of different ages and sizes were used to provide wide variation in chl concentration and IAV so that effects of chl and IAV on visible light reflectance could be evaluated.

Each of the 20 cotton leaves was cut in half along the midrib. Two treatments (noninfiltration and water infiltration) were randomly assigned to leaf halves. Twenty leaf halves were used to make spectrophotometric measurements on noninfiltrated leaf tissue and to assay total chl (5). Chlorophyll concentrations ranged from 4.62 to 11.71 mg/g (mean of 7.77 ± 2.04 mg/g) Spectrophotometric measurements were made on a noninfiltrated leaf half about 8 min after the leaf was harvested.

The other 20 leaf halves were used to determine leaf thickness, area, and percent water content and to make spectrophotometric reflectance measurements on water-infiltrated tissue. Infiltration consisted of replacing air in leaves with distilled water under vacuum. Spectrophotometric measurements were made on an infiltrated leaf half about 12 min after the leaf was harvested. Leaf thickness (range 0.146 to 0.265 mm; mean 0.202 ± 0.037 mm) was measured with a linear displacement transducer and digital voltmeter (4), leaf area was determined with a planimeter, and percent leaf water content (range 75.31 to 81.27%; mean 78.70 1.67%) was determined on an oven-dry weight basis by drying leaves at 68 C for 72 hr and cooling in a desiccator before final weighing.

Weight increase of leaves with infiltration approximates IAV (12). It was calculated by subtracting fresh leaf weight from the leaf weight after it was infiltrated with water and dividing by leaf area (IAV/cm^2) and by leaf volume (IAV/cm^3). Ranges were 3.33 to 9.48 mg/cm^2 with a mean of 6.99 ± 1.81 mg/cm^2, and 201 to 492 mg/cm ± 91 mg/cm^3, respectively.

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 400 to 700-nm wavelength interval relative to a $BaSO_4$ standard. (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.)

Reflectance data for infiltrated and noninfiltrated leaves at the 450-nm (chl absorption band), 550-nm (green reflectance peak), and 680-nm (chl absorption band) wavelengths were correlated with leaf chl concentration, IAV/cm^2, IAV/cm^3, leaf thickness, and leaf water content. Linear and partial regressions were calculated of reflectance at the 680-nm wavelength on chl concentration and IAV/cm^2 (8).

RESULTS AND DISCUSSION

Fig. 1 charts reflectance of noninfiltrated and water-infiltrated cotton leaves over the 400 to 700-nm wavelength interval. Replacing air with water in mesophylls of infiltrated leaves reduced reflectance, compared with noninfiltrated leaves, by partially eliminating cell wall-air interfaces (3, 6, 11). Reflectance was 5.4 and 2.3% less (significant $P = 0.01$) for infiltrated than for noninfiltrated leaves at the 550-nm (green reflectance peak) and 680-nm (chl absorption band) wavelengths, respectively. Results for infiltrated and noninfiltrated leaves were alike at the 450-nm wavelength (chl absorption band).

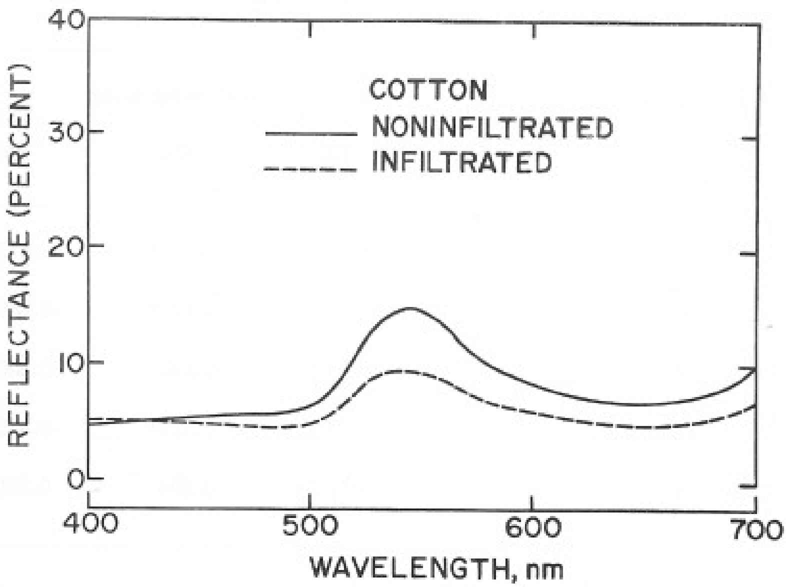

Fig. 1. Average reflectance of 20 noninfiltrated and 20 water-infiltrated cotton leaf halves over the 400 to 700-nm wavelength interval.

Infiltrating cotton leaves with media having larger refractive indices than water would have reduced reflectance more than did water infiltration (3, 11). However, distilled water was used rather than other media so that no residue remained when dry weights of leaves were obtained.

Table 1 gives coefficients for linear correlations of reflectance with chl concentration, IAV/cm^2, IAV/cm^3, leaf thickness, and leaf water content at the 450, 550,and 680-nm wavelengths. At the 450-nm wavelength, the only significant coefficient (r = -0.515*) was for the correlation of reflectance with water content, but this linear relation accounted for only 26.5% (r^2 x 100) of the total variation. Reflectance at the 550-nm wavelength was correlated with chl concentration (r = -0.737**), IAV/cm^2 (r= -0.501*), and leaf thickness (r = -0.479*), but these linear relations of leaf thickness and IAV/cm^2 accounted for only 25.1 and 22.9 % of the total variation, respectively. The coefficient for the correlation of IAV with leaf thickness was r = 0.684**. Reflectance at the 680-nm wavelength was correlated with chl concentration (r = -0.811**), IAV/cm^2 (r = -0.636**), and IAV/cm^3 (= -0.500*). The correlation between chl concentration and reflectance was not improved by expressing chl as mg/cm^2 or mg/cm^3 instead of mg/g of plant tissue.

Table 1. Coefficients for linear correlations of reflectance with chlorophyll (chl) concentration, internal air volume (IAV), leaf thickness, and leaf water content for 20 cotton leaves at the 450, 550, and 680-nm wavelengths.

Comparisons	Wavelength, nm		
reflectance vs.:	450	550	680
Chl	0.000	-0.737**	-0.811**
IAV/cm^2	0.039	-0.501*	-0.636**
IAV/cm^3	-0.054	-0.235	-0.500*
Thickness	0.081	-0.479*	-0.312
Water Content	-0.515*	0.204	0.230

* Significant at 5% probability level.

** Significant at 1% probability level.

Although chl and IAV/cm^2 were related at the 550- and 680-nm wavelengths, data for the 680-nm wavelength were selected for a chl x IAV/cm^2 interaction analysis that follows. Internal air volume interacted with chl concentration to affect reflectance at the 680-nm wavelength. The coefficient for the linear correlation of chl concentration with IAV/cm^2 was 0.707**. Linear regressions of reflectance on IAV/cm^2 + chl concentration (R = -0.816**), of reflectance on chl concentration (r = -0.811**), and of reflectance on IAV/cm^2 (r = -0.638**) were highly significant. Since R = -0.816** is not significantly different from r = -0.811**, IAV/cm^2 appears to be an unimportant variable. Moreover, the linear regression of reflectance on chl concentration remained significant (r = -0.510*) after removing the influence of IAV/cm^2, whereas the linear regression of reflectance on IAV/cm^2 was not significant after removing the influence of chl concentration. However, coefficients of determination (r^2 x 100) show that 66% of the variation is accounted for by the linear regression of reflectance on chl concentration, 26% of the variation is accounted for by the linear regression of reflectance on chl concentration after removing the influence of IAV/cm^2, leaving a difference of 40% (66% minus 26%) for the linear regression of reflectance on the interaction of chl concentration with IAV/cm^2. Partial regression coefficients showed that chl concentration had 5.6 times more effect than IAV/cm^2 on reflectance at the 680-nm wavelength.

Results suggest that reflectance at the 680-nm wavelength was closely associated with chl concentration, but it was modified by the interaction of chl with IAV. Results help explain the light reflectance from crop leaves of different ages and chlorophyll concentrations.

ACKNOWLEDGMENT

This study was supported in part by the National Aeronautics and Space Administration under Contract No. R-09-038-002.

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Description and LANDSAT-1 Remote Sensing of the Rangelands of Hidalgo County, Texas

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ABSTRACT

Hidalgo County, Texas, was the site used to test the feasibility of using data from the first Earth Resources Technology Satellite (LANDSAT-1) to assess agricultural land use and growing conditions. Large areas of rangeland in the county are in three major range sites: deep sand, red sandy loam, and gray sandy loam. Botanical compositions developed from ground data are given for each site.

LANDSAT-1 multispectral scanner data were reduced to digital counts of the area occupied by two major rangeland categories: "mixed shrub" and "grass" associations. From this inventory we estimated 470,000 acres for "mixed shrub" and "grass" associations as compared with 453,000 acres estimated from a ground survey. As read into the data analysis system, these two categories included vegetated areas, such as wildlife refuges, canal and road rights-of-way, rural homesites, and irrigated pastureland. Results indicated that useful range inventories are possible using spectral measurements from space.

Hidalgo County, Texas, has been used as the test site for developing a data analysis system for transforming data from the first Earth Resources Technology Satellite (LANDSAT-1) into assessing agricultural land uses and growing conditions. A county was chosen as the base unit because it is the political unit from which agricultural census data are collected and summarized.

There is little literature available on the range ecosystems of Hidalgo County because it is considered as a part of the South Texas Plains Vegetational Area (5,10). Moreover, many individual rangeland holdings are so large and inaccessible that photography or other imagery is necessary to determine their characteristics and extent. The application of remote sensing to rangeland assessment is well established (1,4,7,8,11,15).

In this paper, we first describe the ecology of Hidalgo County rangelands and then discuss their extent and distribution as determined from LANDSAT-1 multispectral scanner (MSS) data.

Study area. Hidalgo County, Texas (approximately 1,000,000 acres) is located in the southern part of the South Texas Plains Vegetational Area

(Fig. 1). This area is also known as the Rio Grande Plains or Tamaulipan Brushlands (5).

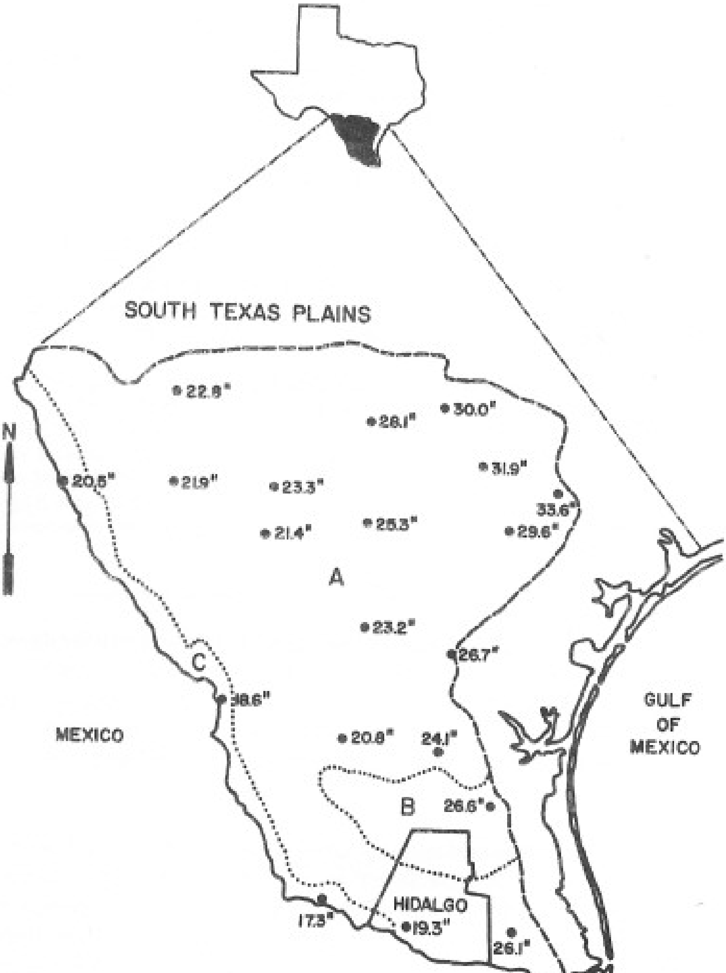

Fig. 1. South Texas Plains Vegetational Area with annual rainfall for selected locations; Hidalgo County is outlined to illustrate its location. Potential vegetation types: (A) Mesquite-Acacia Savanna, (B) Mesquite-Live Oak Savanna, (C) Ceniza Shrub (from Kuchler (13).

The topography of Hidalgo County is level to gently rolling and elevations range from 40 to 275 ft. above sea level.

The climate of this area is mild with short winters and relatively warm temperatures throughout the year. Summer temperatures and evaporation rates are high. Average annual rainfall is approximately 20 inches (6). The lowest average rainfall occurs in January and February, while the highest occurs in 30-day periods centered on June 1 and September 10. July and late June and early August are usually dry, but long rainless periods are common any time of the year.

Hidalgo County has all three of the potential vegetation types described by Kuchler (13) for the South Texas Plains Vegetational area (Fig. 1). However, the Ceniza shrub type occurs only in the extreme southwestern part of the county and represents only a very small acreage (area C, Fig. 1). Thus, it was not sampled in this study. The other two potential vegetation types, the Mesquite-Acacia Savanna (central and southern part of the county), and the Mesquite-Live Oak Savanna (northern part of county) represent large acreages of the county. Some of the native vegetation of these areas has been cleared and the land has been seeded in grass. Range improvement is more prevalent in the Mesquite-Acacia Savanna type, since the soils are more productive and generally respond well to management.

Three major range sites are found in Hidalgo County. One is the deep sand range site that covers the entire northern part of the county (area B, Fig. 1). Two other major sites are the gray and red sandy loam range sites (ares A, Fig. 1) in the western part of the county. The gray sandy loam is found in the lower and the red sandy loam in the upper portion.

METHODS

Vegetational sampling technique. Two sites from each of the three major range sites in Hidalgo County were chosen to determine their vegetational composition. The line transect method, described by Canfield (3), was used to determine composition of woody plants. Herbaceous plant composition on each range site was determined by the point frame method (19). Both sets of data were used to describe each site botanically. No brush control had been practiced on any of the range sites studied.

Computer technique. The remotely sensed data were from LANDSAT-1 launched 22 July 1972, and passing over the test sites every 18 days since. For dates when clouds did not obscure the ground scene, MSS data were supplied by the National Aeronautics and Space Administration's (NASA) National Data Products Facility at Greenbelt, Maryland, in the form of computer compatible digital magnetic tapes and images at the scale of 1:1,000,000 (14).

The 21 January 1973 overpass provided digital counts for a 100 by 100 nautical mile area including Hidalgo County. All four MSS bands were used, covering the 0.4 to 1.1-um spectral region. At the same time as the LANDSAT-1 overpass, ground reconnaissance provided ground truth data on crop, soil, and rangeland conditions for 1,400 fields in Hidalgo County.

The MSS digital data and ground truth data for each field were used to determine the major distinguishable categories for this LANDSAT-1 overpass.

Twenty of the 1400 county fields (two vegetable, five citrus, three grass, four mixed shrubs and six bare soil) were selected as representative (check fields) for computer classification of the major categories. Two spectrally different bare soil categories, one for the McAllen-Brennan and Harlingen, and one for the Mercedes-Raymondville soil associations, were combined into one category for computer acreage estimation calculations. A large lake was selected as representative of water for computer acreage estimation.

The computer was programmed to identify the major categories by comparing the spectrum of each remote sensing unit on the ground (pixel) with the spectra of each of the 20 fields. The algorithm for this procedure is known as the maximum likelihood classifier (9). The computer-implemented classifier identified each of the 849,000 MSS pixels in the county as one of the five training categories it most closely resembles. The optimum MSS bands 4 (0.5 to 0.6 um), 5 (0.6 to 0.7 um), and 7 (0.8 to 1.1 um) were used in the classifier. These three bands were selected as best for the purpose, using an optimization program, CHOICE (12). If the pixel did not resemble any of the reference categories from the 20 fields, it was classified as a threshold or unidentified category.

The number of pixels classified into each of the six categories was scaled into acreage estimates by multiplying the number of pixels in each category by the ground area (1.155 acres) occupied by each pixel. A line printer recognition map of Hidago County was developed by assigning printer symbols to each reference category. The actual recognition map represents a 10 to 1 reduction of the original 849,000 pixels. The reduction was accomplished by further classifying successive 5 by 5 matrices of pixels (25 pixels) as the reference category occupying a majority of the pixels in each matrix. Each matrix classified in the original data was then used as a pixel in a new set of data. Then every other pixel of alternate scan lines was used to produce the recognition map shown in Fig. 2 from the new set of data. Due to the sparse distribution of threshold pixels throughout the county, this land-use category did not appear on the line printer recognition map of Hidalgo County (Fig. 2) after the reduction process. Each symbol in this map represents 115.5 acres. Acreage estimations, using 849,000 pixels, are given in Table 1 using a modification of Anderson's land-use classification scheme (2).

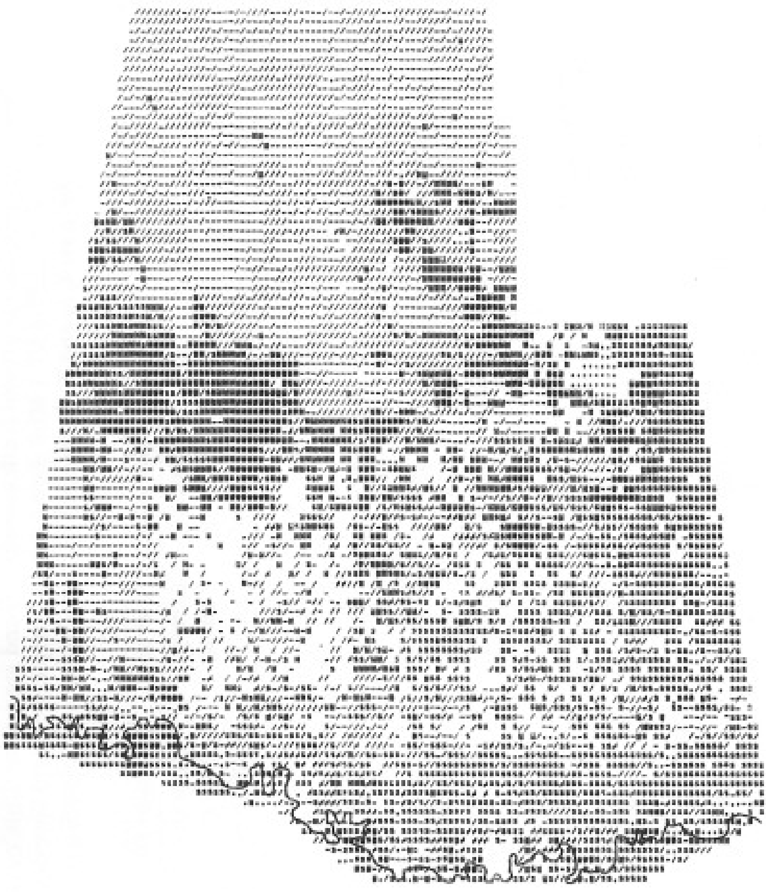

Fig. 2. Line printer recognition map of Hidalgo County produced by assigning symbols to various vegetation, soil, and water categories of the county. Land use categories corresponding to printout symbols are: Blank = citrus, -/ = vegetables, ·= mixed shrubs, / = grass, MW = McAllen soil, $ = Harlingen soil, and · = water.

RESULTS AND DISCUSSION

Ground truth data. Table 2 represents the major plant species of the rangelands of Hidalgo County, Texas and the three major range sites on which they dominate.

Table 1. Comparison of ground truth acreage (ground survey for Hidalgo County) with computer estimated acreage (using LANDSAT-1 MSS digital data of complete county) for categories surveyed on 21 January 1973 (MSS channels 4, 5, and 7). Categories are listed using a modification of Anderson's land use classification system.

Land use categories	Ground truth acreage: Mean size in acres (Thousands)	Ground truth acreage: Percent of county	Computer estimated acreage: Mean size in acres (Thousands)	Computer estimated acreage: Percent of county	Difference computer to ground truth (Acres in thousands)
01 Urban	-	-	-	-	-
02 Agriculture	487	51.8	454	46.2	33
03 Rangeland	453	48.2	470	48.0	17
01 Grass association	98	10.4	244	24.9	146**
05 Mixed shrub association	315	33.5	226	23.1	89*
06 Non-agricultural	40	4.3	-	-	
05 Water	-	-	6	0.7	
Threshold	-	-	50	5.1	
Total	940	-	980	100.0	

* Significant at the 5% probability level.
** Significant at the 1% probability level.

Table 2. Major plant species of the rangelands of Hidalgo County, Texas and range sites on which they dominate.

Species [1]	Site[2]
Woody	
Acacia greggii Gray	1
A. rigidula Benth.	3
Castela texana (T. & G.) Rose	3
Celtis pallida Torr.	1,2,3
Colubrina texensis (T. & G.) Gray	2,3
Condalia hookeri M. C. Johnst.	1,2
Eysenhardtia texana Scheele	2
Jatropha dioica Cerv.	2
Karwinskia humboldtiana (R. & S.) Zucc.	2
Lantana horrida H. B. K.	3
Leucophyllum frutescens (Berl.) Johnst.	3
Lycium berlandieri Dun.	1,2,3
Opuntia leptocaulis DC.	1
O. lindheimeri Engelm.	1,3
Porlieria angustifolia (Engelm.) Gray	3
Prosopis glandulosa Torr.	1,2,3
Salvia ballotaeflora Benth.	2,3
Schaefferia cuneifolia Gray	2,3
Viguiera stenoloba Blake	3
Zanthoxylum fagara (L.) Sarg.	2
Grasses	
Aristida purpurea Nutt.	1
Bouteloua repens (H.B.K.) Scribn. & Merr.	2
B. Trifida Thurb.	3
Brachiaria ciliatissima (Buckl.) Chase	1,2
Cenchrus incertus M. A. Curtis	1
Chloris cucullata Bisch.	1,2,3
Eragrostis curtipedicellata Buckl.	3
E. oxylepis (Torr.) Torr.	1,2
E. sessilispica Buckl.	1,2
Leptoloma cognatum (Schult.) Chase	1
Panicum capillarioides Vasey	1
Pappophorum bicolor Fourn.	3
Paspalum setaceum Michx.	1
Setaria firmula (Hitch. & Chase) Pilger	1
S. leucopila (Schribn. & Merr.) K. Schum.	3
S. texana W. H. P. Emery	3
Sporobolus cryptandrus (Torr.) Gray	2,3
Trichachne californica (Benth.) Chase	3
Trichloris pluriflora Fourn.	3

Forbs	
Acalyphya radians Torr.	1
Ambrosia psilostachya DC.	3
Cassia texana Buckl.	1,2
Cynanchum barbigerum (Scheele) Shinners	1
Dalea pogonathera Gray	2
Dyssodia tenuiloba (DC.) Robins	2,3
Evolvulus alsinoides L.	2,3
Melampodium cinereum DC.	3
Menodora heterophylla Moric.	3
Parthenium confertum Gray	3
Physalis viscosa L.	1
Rhynchosia americana (Mill.) C. Metz.	1
Rivina humilis L.	1,2,3
Sphaeralcea pedatifida Gray	3
Verbena plicata Greene	1,3
Waltheria indica L.	2
Zornia bracteata J. F. Gmel.	2

1 Plant names are according to Correl and Johnston (5).

2 Site 1 = deep sand; Site 2 = red sandy loam; Site 3 = gray sandy loam.

The deep sand range site is an open, brushy site with many grasses and forbs associated with Nueces, Sarita, and Falfurrias soils. This site is best characterized as a savanna type with large mature mesquite trees (*Prosopis glandulosa*) scattered in small motts, or singly over grasslands.

The red sandy loam range site is a moderately dense mixed brush site associated with Delmita-Randado soils. It supports a variety of woody plants, grasses, and forbs. It is characterized by mostly low brush species, except for occasional large mesquite trees.

The gray sandy loam range site is a mixed brush site associated with Brennan, McAllen, and Pharr fine sandy loam soils. These are very productive soils that support a large variety of woody plants, grasses and forbs. This site supports a dense stand of brush.

Satellite data. Table 1 and Fig. 2 represent the results of the LANDSAT-1 MSS remote sensing data of Hidalgo County. In Table 1, "agriculture" refers to total land used for row and fruit crops. For rangeland acreage there is no significant difference (0.01 probability level) between ground truth (453,000 acres) and computer predicted acreage (470,000 acres). The non-agriculture acreage (40,000 acres) was included in the total rangeland because natural vegetation (grass, brush, forbs) was growing on the majority of these areas. The computer classified such pixels into either mixed-shrub or grass association acreage.

Ground truth and computer data for rangeland acreage are larger than the 350,000 acres estimated for rangeland in the northern and extreme western parts of the county by the Texas Conservation Needs Committee (18) because the irrigated pastureland in the county was included in both data estimates. This inclusion raises the rangeland acreage on a county-wide basis since the southern half of the county has numerous irrigated pastures and small to medium-sized blocks of native vegetation, like the Santa Ana National Wildlife Refuge.

The computer classified the rangeland area into either a grass or mixed shrub association. The ground truth data was used to identify a given field as grass if herbaceous species were dominant and as brush or mixed brush if woody plants were dominant. From the computer printout of Hidalgo County (Fig. 2) evidently the computer classified large areas of the county as grass. Table 2 shows that the computer classified 244,000 acres of the county as grass, whereas the ground truth estimate was only 98,000 acres. Within the native rangeland area, brush has been controlled on 80,000 acres and the land seeded to grass. This large acreage comprised of herbaceous biomass is scattered throughout the extreme western, central, and northern half of the county where the symbol (/) for grass is most concentrated on the computer printout (Fig. 2).

The ground truth acreage estimate for mixed shrubs (Table 1) was 315,000 acres, while the computer estimate was 226,000 acres. In the ground truth data much native rangeland was called mixed shrubs because woody plants comprised more total biomass than did herbs. When viewed from the LANDSAT-1 MSS, however, some of these areas were sensed as grass areas from the mixed shrubs or woody plants. The symbol (-) for the mixed shrub category is heavily concentrated in the northern half and the extreme western parts of the county on the computer printout (Fig. 2).

The computer recognition and ground truth acreages differ mainly because the computer classified every 1.155 acre pixel in the county, including the legal description road rights-of-way, canal banks and borrow ditches, field boundaries, rural homesites, urban area, etc., whereas from ground truth data, fields only were classified on the basis of land use. Many of the legal description components not taken into account by ground truth data had natural vegetation growing on them, thus they were classified by satellite data into either the grass or mixed shrub association. Thus, the computer acreage estimates for rangeland were larger than the ground truth estimates and the computer acreage for the county was 40,000 acres greater (Table 2) than the ground truth acreage.

CONCLUSION

The LANDSAT-1 MSS inventory of range resources estimated rangeland at 470,000 acres as compared with a ground truth survey estimate of approximately 453,000 acres. These data indicate that useful range inventories are possible using spectral measurements from space.

ACKNOWLEDGMENT

This work was supported in part by the National Aeronautics and Space Administration under Contract No. S-70251-AG.

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