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# RIO GRANDE VALLEY HORTICULTURAL SOCIETY

## Volume 30, 1976

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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 of Texas. It is the Society's aim to stimulate interest in research and its practical application to the Valley's problems with fruit, vegetables, and ornamentals.

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

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

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

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

*Dr. Ben Villalon*
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**Mr. Henry E. Link**

**Recipient of the**
**Arthur T. Potts Award**
**1975**

Mr. Henry E. Link arrived by train at Mercedes in the Lower Rio Grande Valley on April 9, 1926, after graduating from Virginia Military Institute. His avid interest in plants became an avocation on November 1, 1939, when he opened Link Floral Nursery for business in an adobe and tile-roofed building in Weslaco.

Mr. Link has introduced many plant species to this area, and he participated in many beautifying projects including planting the ash trees in Harlon Block Park, the *Cocus plumosa* palms along business 83, and the plants on Knapp Memorial Hospital's Landscape.

In 1955, Mr. Link served as president of the Texas Avocado Society when it merged with the Texas Grape Society and the Rio Grande Valley Horticultural Club to form the Rio Grande Valley Horticultural Society. Since that time, he has served as an officer in the society.

For 37 years, the Link Floral Nursery's tropical garden on business Highway 83 has been open with signs inviting people to roam at will without guides. Many Valley residents, winter visitors, and tourists are grateful to Mr. Link for promoting the aesthetic appreciation of horticultural plants.

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

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**Program of the Thirtieth Annual Institute**
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**February 3, 1976**

MORNING SESSION: Edward Cox—Presiding

Address of Welcome .................... Dr. Roger F. Albach, President
RGV Horticultural Society

"Star Ruby Status Report" .......................... Dr. John E. Fucik
Acting Director, Texas
A&I University Citrus
Center, Weslaco

"The History and Current Status
of the Mediterranean Fruit Fly
in North America" ................................ Robert H. Rhode
Citrus Entomologist,
Citrus Insects,
USDA, ARS, Weslaco

"Citrus Production Costs for 1976" .................. Alan W. Reichardt
Area Economist-
Management, Texas
Agricultural Extension
Service, Weslaco

"Recent Development in Pecan
Production" .................................... Dr. Dan J. Hanna
Resident Director,
Texas A&M University
Agricultural Research
Center, El Paso

Presentation of the Arthur T.
Potts Award ................................ Dr. Roger F. Albach,
President

AFTERNOON SESSION: Dr. Lavern W. Timmer—Presiding

"Vegetables for the Rio Grande Valley" ................ Panel Discussion:

"Variety Selection" ............................... Paul W. Leeper
Professor, Horticulture,
Texas Agricultural
Experiment Station
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"Cultural Hints" . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Dr. Jerry Parsons
Area Vegetable
Specialist, Texas
Agricultural Extension
Service, San Antonio

"Pest Control" . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . James A. Deer
Area Entomologist,
Texas Agricultural
Extension Service,
Weslaco

"Vegetable Diseases" . . . . . . . . . . . . . . . . . . . . . . . . . . Dr. Jose M. Amador
Area Plant Pathologist,
Texas Agricultural Extension
Service, Weslaco

"Preservation of Home Garden Produce" . . . . . . Mrs. Barbara L. Fowler
County Extension Agent,
Texas Agricultural Extension
Service, Edinburg

"Unfinished Miracles" . . . . . . . . . . . . . . . . . . . . . . . . . A film on agricultural
research in the United States

EVENING SESSION: Dr. Roger F. Albach—Presiding

"Indoor Landscaping" . . . . . . . . . . . . . . . . . . . . . . . . . . . Mrs. John W. Deaton
The Flower Pot,
Harlingen, Texas

"Special Fruit in the Valley Garden" . . . . . . . . . . . . . Dr. Calvin G. Lyons, Jr.
Area Horticulturist,
Texas Agricultural Extension
Service, Weslaco

**TALK PRESENTED AT THE 30TH ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY**

## The History and Current Status of the Mediterranean Fruit Fly in North America

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The extensive geographical distribution and wide range of host fruits attacked by the Mediterranean fruit fly *Ceratitis capitata* (Wiedeman), ranks this insect as the most destructive pest of citrus and numerous other tropical fruits. Of its 200 or more host fruits, over half are of economic importance. Many deciduous fruits as well are susceptible to its ravages. Infestations in stone fruits of up to 100% have been reported from some Mediterranean countries. Losses of 50% in citrus have occurred in Greece, and citrus growers in Costa Rica and Nicaragua commonly suffer losses ranging from 30 to 40%.

From its native habitat in northern Africa the "medfly", as it is commonly called, made its way many years ago to the Mediterranean region from where it acquired its name. This world traveler subsequently hitchhiked to South Africa, South America, Australia, the Hawaiian Islands, and other islands of the Atlantic and Indian Oceans.

The medfly adult is somewhat smaller than the housefly with the colors brown, black, yellow, and white arranged in a characteristic pattern. The wings are banded and held in a drooping position. The black spots on the thorax, the two white bands on the yellowish abdomen, and the black and yellow markings on the wings are distinguishing features for this species.

In cool regions the medfly winters as a pupa or adult. In warmer areas where suitable host fruits are available, reproductive activity continues throughout the year. The female deposits 15 to 20 eggs at a time beneath the surface of the fruit. She may pierce the fruit with her ovipositor or lay additional eggs in the same hole made by other females. A single female may lay 1,000 or more eggs in her lifetime. The eggs hatch in 2 to 20 days depending on the temperature. The young larvae burrow in the pulp for 10 days to 6 weeks before completing growth at which time they are a little more than ¼ inch long. The mature larvae then leave the fruit and form pupariums in the soil within an inch or two of the surface or under other surface litter.

An interesting feature of the larva which serves as a field aid to separate the medfly from larvae of other fruit flies native to North America, is its manner of "jumping" or "popping." If placed on a hard, dry surface, the larva will soon bend in a circle and grasp the posterior spiracles with its mouthhooks. The larva will then suddenly straighten, and the released tension will cause it to leap several inches into the air. This movement assists the larva in seeking out a favorable spot for pupation which is completed in 10 to 50 days.

Under favorable conditions the life cycle may be completed in 17 days, and life cycles of 3 months duration are not uncommon. In various parts of the world, there may be from 1 to 12 or more generations a year.

On several occasions during the past 46 years, the medfly has established itself briefly in the continental U.S. In April 1929, the medfly invaded 20 counties in Florida, which incorporated 72% of the bearing citrus trees of the state. Following a sweeping 18-month campaign of spraying and the disposal of susceptible fruits, this pest was eradicated at a cost of about 7.5 million dollars. In April 1956, the medfly was detected near Miami, Florida, and before it was brought under control it had spread over 28 counties. By means of extensive aerial applications of bait sprays throughout a 16-month period, the medfly was again eradicated at an expenditure of approximately 10 million dollars. Limited infestations of this insect reoccurred in 1962 and twice in 1963 in Florida and in 1966 at Brownsville, Texas. Through the aerial release of protein-hydrolysate-malathion bait sprays, these later outbreaks were eliminated at a cost of 1.3 million dollars.

On September 25, 1975, the first known infestation of the medfly in California was recovered from a McPhail trap near Venice Beach in Culver City, a suburb of Los Angeles. The proximity of the find to a marina and the fact that one or more yachts recently had returned from Central America led officials to suspect that medfly infested fruits were introduced by this means. Subsequent additional finds within a 1 square mile area of medfly adults in traps and larval infestations in peaches brought about a massive federal-state-county eradication effort. A critical core area which lies within an 80 square mile quarantine zone is being treated with soil insecticides and the discrete application of protein-hydrolysate-malathion bait sprays to the foliage of susceptible host plants. In addition, approximately 25 million laboratory reared and sterilized medflies per week, supplied by the USDA, ARS facility in Hawaii, are being released by air in the core area. The use of the sterile insect release technique is based on a principle conceived by E. F. Knipling of the USDA in 1938 that if insects are reared, sterilized, and released in numbers exceeding those present in the wild population, the resulting crossmatings will suppress the reproductive potential of the field population. In California it is anticipated that the mass release of sterile flies in combination with other suppressive measures will result in the eradication of the medfly within the next 4 to 6 months.

In April 1955, medfly infestations in oranges were discovered in the highland plateau of Costa Rica near the capitol city of San Jose. This marks the first appearance of this pest on the North American Continent since its eradication in Florida in 1929 to 30. Initial attempts made by the Costa Rican Government to eradicate the medfly with insecticides from the locally infested areas were abandoned after surveys disclosed the general presence of this pest throughout the coffee-producing regions of the central plateau. Instead, in 1957, the newly created Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA) undertook the responsibility of preventing the spread of the medfly to other Central American countries; OIRSA, an international regional organization funded by annual contributions from its member countries, is concerned with the control or eradication of plant and animal pests and diseases that threaten the agricultural economy of the five Central American countries, Mexico, and Panama. Nevertheless, despite regulatory and quarantine measures instituted by OIRSA to halt the medfly advance, the pest was detected in Central Nicaragua in 1959 and in Western Panama in 1962.

In Central America, citrus is the major commercial host fruit crop — except coffee — grown on an economic scale. Some small plantings of peaches are found in Costa Rica and an expanding deciduous fruit industry is present in Guatemala. Although losses in coffee bean production caused by medfly infestations are estimated to be about 1%, the extensive cultivation and fruiting characteristics of this crop permit the development of high medfly populations during the harvest season. After the coffee crop is terminated, the medfly attacks nearby maturing citrus with devastating results.

In an effort to develop biological control methods to reduce native medfly populations, OIRSA, with assistance provided by the United States and the Interamerican Institute of Agricultural Sciences, Turrialba, Costa Rica, initiated a laboratory rearing program in 1958 for the production of medfly parasites and in 1961 began investigations on medfly sterilization procedures using gamma radiations.

In 1964, laboratory procedures in medfly rearing and sterilization had developed sufficiently to permit a pilot field test. Under a joint US/AID-OIRSA agreement, 1 million sterile medflies per week were released over a 1 square mile area on the peninsula of Puntarenas, Costa Rica. The results of this test were sufficiently encouraging so that OIRSA, with the United Nations Development Programme (UNDP) support entered into a cooperative program in 1965 with the International Atomic Energy Agency

(IAEA) to determine the feasibility of eradicating the medfly from Central America by means of the sterile male technique. In an experiment conducted from September 1968 to May 1969, approximately 40 million sterile medflies were released each week over a non-isolated 18.5-square mile (48 $km^2$) coffee and citrus area in Nicaragua. Results of this test demonstrated that average deposition of viable medfly eggs, larval infestations in coffee fruits, and recoveries of pupae from mandarin oranges were at least 90% less in the release area than in the two controls. It was concluded from this experiment that if complete isolation had existed in the test area, the medfly would have been eradicated.

As mentioned previously, the sterile insect release technique consists of the rearing, sterilization, and periodic release of insects in sufficient numbers to dominate the reproductive capability of the wild population. In the Central American program, 40 to 70 million medflies were reared weekly in the San Jose, Costa Rica laboratory on a larval medium composed chiefly of sugar, dried yeast, and sugarcane bagasse. The laboratory stock populations were confined in cages holding from 25 to 50 thousand adults. The female flies deposited their eggs through small perforations made in cylindrical plastic containers inserted through the sides of the cages. The eggs were then washed from the egging devices, measured, and distributed over trays filled with larval medium. The developing larvae were held for 9 days in screened cabinets at which time the rearing trays were inverted to permit the mature larvae to leave the medium and drop to a collecting bin at the bottom of each cabinet. The larvae were then distributed over a layer of sawdust contained in shallow boxes to permit pupation. After 3 days the pupae were separated from the pupation medium using a sifter and the pupae were then held naked for 4 days in shallow trays under controlled conditions of temperature and humidity. At 7 days of age — or 1 day before adult emergence — the pupae were exposed to 9 kr of gamma radiations, marked with a flourescent dye, and placed in lots of 5,000 in number 12 paper bags filled with strips of wood excelsior. On the second day following the sterilization treatment, cardboard cartons containing bags of the now emerged flies were loaded aboard C-47 airplanes of the Nicaraguan Air Force and flown to the test site in Nicaragua for distribution. One bag was dropped manually into a release chute at about 328-foot (100 m) intervals along flight lines spaced 820 feet (250 m) apart. A pair of blades set on each of two opposing sides near the end of the chute opened the bags as they were drawn through by suction.

Except for medfly infestations in the two major coffee producing areas of southern and northeastern Nicaragua, the spread of this pest to other parts of the country was relatively slow. The semi-arid conditions and lack of extensive host material in northern and western Nicaragua and southern El Salvador were considered primary factors inhibiting the voluntary northward movement of the medfly. Occasional outbreaks of this insect in small towns of northern Nicaragua along the Inter-American Highway were quickly detected and eradicated. The 1969 conflict between El Salvador and Honduras resulted in the closing of their respective frontiers and the suspension of commerce between the two countries. Consequently, commercial traffic destined for northern Central America was diverted up the west coast of Nicaragua and across the Gulf of Fonseca by ferry to El Salvador. This route circumvented the internal quarantine station on the Inter-American Highway north of Managua, Nicaragua and the inspection station at the Nicaraguan-Honduras border. Quarantine inspections on the improvised northward route within both Nicaragua and El Salvador were nonexistent or at best rudimentary for a considerable period of time. Conceivably, this situation could have been a causative factor in the spread of the medfly to El Salvador, the presence of which was announced by that Government on April 2, 1975.

Subsequent trapping surveys in El Salvador disclosed medfly infestations throughout a 1,544 square mile (4,000 $km^2$) area. Alert to the danger that medfly presence in El Salvador represented to their fruit industries, the neighboring countries of Guatemala and Honduras immediately began intensified trapping operations. The results soon disclosed an infested area of 232 square miles (600 $km^2$) in Guatemala contiguous to the El Salvador border and six outbreaks in isolated mountain valleys of Honduras lying along the El Salvador-Honduras frontier.

The medfly infestations in Guatemala extend to the town of Esquintla situated in a major fruit producing area about 90 miles from the Mexican border. This outbreak constitutes an imminent threat to Mexico because of the virtual lack of ecological barriers which would prevent the medfly from moving of its own volition into the coffee growing regions lying along Mexico's southern border. The Government of Mexico has taken positive action in its concern over the presence of medfly in Guatemala. Recognizing the potential danger this pest represents to its fruit industry, Mexico recently appropriated an initial sum of 1 million dollars for the purchase of material and equipment to be used against the medfly in Guatemala. It is understood that USDA/APHIS in its cooperative programs with Sanidad Vegetal of Mexico is proceeding with the placement of 40,000 medfly traps throughout Mexico. Hopefully, positive gains will be made in attempts to eradicate or contain this pest in Guatemala. However, if the medfly succeeds in moving northward from its present position, the continuity of host fruits extending into Mexico, the uncontrolled movement of field workers across frontier forest trials, and the tourist and commercial traffic between the two countries weigh heavily against the southern border regions of Mexico remaining free of the medfly for any determinable time.

It has been proposed that the geographical and evironmental character of lower Mexico at the Isthmus of Tehuantepec offers the only defensible location to establish a quarantine barrier beyond which the medfly would not be permitted to exist. The semi-arid conditions along the Pacific coast with its apparent scarcity of suitable host material would be less habitable for the medfly than the more tropical Gulf Coast. Even here the possibility of relatively low host fruit density may limit native fly populations to a level manageable by periodic bait spray applications, sterile fly releases, or other control measures under investigation by the Agricultural Research Service.

This proposed strategy for the protection of the U.S. and Mexican fruit industries would require constant medfly surveilance throughout the Republic of Mexico, particularly the susceptible Gulf Coast region. Any outbreaks occurring beyond the barrier zone must be detected and quickly eradicated. Failure to contend successfully with such an eventuality will allow the medfly to move northward along a nearly continuous chain of host fruit areas which extend to within 100 miles of our southeastern Texas border. This distance offers no real security for the Rio Grande Valley's citrus industry. Towns and ranches with host material capable of supporting the medfly as well as possible wild host fruits are to be found throughout this area. In addition, the continual flow of vehicles northward from Mexico would present unlimited opportunity for the medfly to be transported by mechanical means to susceptible U.S. border regions.

Experience in the U.S. has shown that medfly infestations can be eradicated by protein-hydrolysate-malathion bait sprays applied by air. However, the repeated use of these materials over urban areas may bring about strong public objection to their continuance. The effectiveness of the sterile insect release method against the medfly has been demonstrated in field tests in several world areas. Although sophisticated and costly, this technique has the advantage of being non-polluting, specific against the target insect, and resistant species do not develop as with the extended use of insecticides.

As an eradication measure, sterile insect releases of the proper magnitude are effective under isolated conditions, but thier usefulness is nullified in areas subject to a constant inflow of wild flies. Compared with insecticide treatments, the economic feasibility of the sterile insect method to control wild fly populations has yet to be properly evaluated. Now under development, the use of attractant-chemical mixtures utilized in various manners shows promise as a method of controlling the medfly. The eradication of the oriental fruit fly from large areas has been accomplished using this technique. Research on this method must be accelerated. Large area field tests using present attractants are needed to determine the effectiveness of this treatment against high medfly populations. A search must also be made to discover new compounds which exhibit greater attractancy than the materials presently available.

For further reading please consult the following references:

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## Effect of Irrigation and Soil Management Practices on the Incidence of *Phytophthora* Foot Rot of Citrus

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### ABSTRACT

Under drip irrigation, *Phytophthora* foot rot incidence, recovery of *Phytophthora* from soil, and tree losses were considerably higher on trees planted on level ground than those planted on raised ridges. Tank and flood-irrigated trees on level ground had a higher incidence of foot rot than those under drip irrigation on raised ridges, but a lower incidence than on those under drip irrigation on level ground. The high incidence of foot rot on trees under drip irrigation on level ground was attributed to favorable conditions for infection caused by saturation of polyurethane tree wraps by irrigation water. Loosening of the soil at the tree site prior to planting reduced foot rot incidence slightly. Foot rot incidence and tree losses were higher on Star Ruby than on Webb Redblush grapefruit.

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*Phytophthora parasitica* Dast. is a common pathogen in Texas citrus orchards (6). The most serious damage is due to decline and death of trees girdled by foot rot on the lower trunk, with the greatest tree losses generally occurring on the most susceptible cultivars, Marrs Early orange [*Citrus sinensis* L. (Osbeck)] and Star Ruby grapefruit (*C. paradisi* Macf.) (5, 7). Control measures such as budding trees on a resistant rootstock at least 6 inches above the soil line, fumigating nursery soils and tree planting sites, and eliminating excess moisture by various cultural practices are usually recommended (1, 2, 5). While practices such as improvement of subsurface drainage, removal of excess surface water, and planting trees above ground level would be expected to reduce foot rot incidence, little information is available on the degree of control to be expected under specific conditions. High water tables and high percentages of soil organic matter increases fibrous root rot of citrus (4). Banking of tree trunks with soil increased not only the rate of infection, but also the severity of the disease (8).

The present study was undertaken to determine the effect of irrigation systems and various soil management practices on the incidence of foot rot on two grapefruit cultivars.

## MATERIALS AND METHODS

Old-line Webb Redblush and young-line Star Ruby grapefruit were budded 5 to 6 inches above the soil line on sour orange (*C. aurantium* L.) rootstock in the nursery. Balled and burlapped trees were transplanted to the orchard site in November, 1973, and planted on a 24 x 14-ft spacing. Since the nursery site was infested with *P. parasitica* most of the trees probably carried the fungus, but none had actively gumming lesions aboveground at planting time. Since the orchard site had not been planted to citrus previously, it was presumed to be free of *P. parasitica*.

The orchard used for the study was planted on Mercedes clay, a fine-textured, poorly drained soil usually considered unsuitable for citrus. Star Ruby grapefruit was planted in one-half of the orchard and Webb Redblush in the other half. In an attempt to improve water penetration and alleviate drainage problems, trees were planted in rows receiving the following preplant soil treatments: 1) no treatment (Fig. 1A); 2) formation of broad-based ridges 12 inches higher than the surrounding soil surface (Fig. 1B); 3) chiseled 18 inches deep; and 4) chiseled 18 inches deep, then broad-based ridges formed. Each treatment was applied to a 25-tree row and replicated five times on each variety in a randomized complete block design. Four additional treatments which loosened the soil in and around the planting hole were used at planting time: a) standard technique, planting hole made with an 8-inch diameter auger; b) single planting hole made with a 24-inch diameter auger; c) double planting home made with a 24-inch auger; and d) triple planting hole made with a 24-inch auger. Planting-hole treatments were super-imposed on preplant row treatments and arranged systematically within each row. After planting, a no-tillage system was used with weeds controlled by herbicides. Drip irrigation was used on all except three rows of Webb Redblush and four rows of Star Ruby. On these rows planted on level ground, 4-ft diameter rings of soil were formed around each tree and approximately 25 gal of water were delivered into the rings from a tank wagon as needed. After July 1975, these seven rows were strip watered by forming irrigation borders on either side of the row and flooding an 8-ft wide strip down each row.

In November each year, tree trunks were painted with a banking compound containing 2.5% copper fungicide and 2.5% captan to prevent *Phytophthora* infection and wrapped with polyurethane mats (approximately 14 x 30 x 1 inch) for freeze protection (9). Wraps were removed in early March. The number of trees with foot rot on the scion or rootstock and the percentage of the trunk circumference with active gummosis were recorded in April, June, and October, 1975. Soil samples for *Phytophthora* isolations were taken about 2 ft from the trunk of the tree in June and in August, 1975. Three samples were taken from each row in the orchard in such a manner that the planting-hole treatments were equally represented.

*Phytophthora* isolations were made using the lemon-trap technique (3) except calamondin fruit (*C. reticulata* var *austera?* x *Fortunella* sp.?) were substituted for lemons. Each site was rated positive if *Phytophthora* was recovered on either sample date. The total number of trees replaced since planting because of foot rot damage or dying from the disease was recorded in May, 1976.

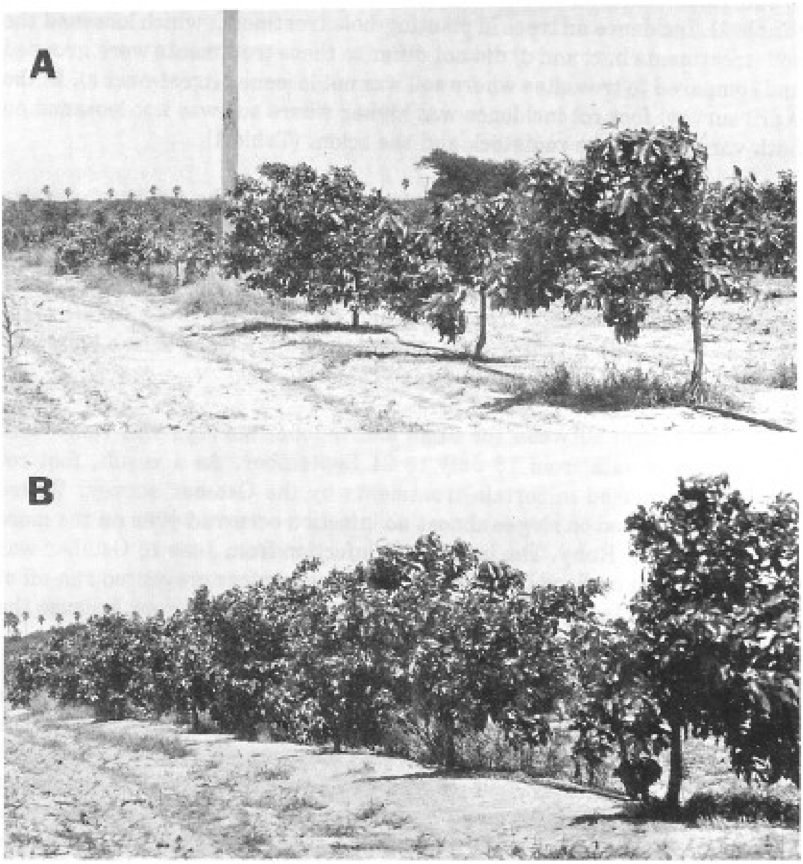

**Fig. 1.** Star Ruby grapefruit, 2.5-years-old under drip irrigation planted A) on level ground and B) on a raised ridge. Note the larger number of replacements required on level ground.

## RESULTS

When the polyurethane wraps were removed in March 1975, a high incidence of foot rot was noted in spite of the preventative trunk treatment with banking compound. Since budunions were well above the soil line, most of the infection was on the rootstock rather than the scion. Foot rot incidence was very high on trees planted at ground level with almost no foot rot on trees planted on ridges (Table 1). Chiseling had no effect on foot rot incidence. In April, foot rot incidence was greater on Star Ruby than on Webb Redblush scions, but was less on the rootstock under Star Ruby (Table 1). Incidence on trees in planting-hole treatments which loosened the soil (treatments b, c, and d) did not differ so these treatments were grouped and compared to tree sites where soil was not loosened (treatment a). In the April survey, foot rot incidence was higher where soil was not loosened on both varieties on the rootstock and the scion. (Table 1).

After the polyurethane wraps were removed, the weather was dry with less than 0.2 inch of rain from March until the last week of May. By the June survey nearly all lesions had healed and were no longer producing gum. Since incidence was low in the June survey no differences were apparent between the soil treatments and varieties. However, where trees were watered with a tank wagon, infection on Star Ruby scions increased from 3.1 to 4.2% from April to June (Table 1).

The period between the June and October surveys was rainy with 17.3 inches of rain from 13 July to 21 September. As a result, foot rot incidence increased in certain treatments by the October survey. Where trees were planted on ridges almost no infection occurred even on the more susceptible Star Ruby. The increase in infection from June to October was especially great on flood irrigated trees where borders prevented run-off of surface waters. Infection was confined mostly to the rootstock because the budunions were high and the standing water shallow.

*Phytophthora* isolations indicated that the fungus was present in the entire orchard. *Phytophthora* was isolated more frequently where the incidence of foot rot was the highest, i.e., on trees planted at ground level and in the Star Ruby half of the orchard. The higher recovery of *Phytophthora* from these areas is probably the result of more favorable conditions for multiplication of the fungus rather than introduction of larger numbers of propagules with the trees which were planted in these areas.

The greatest number of replacements were required for Star Ruby trees under drip irrigation planted at ground level. Few replacements were required for the trees planted on ridges. The rate of replacement was higher for Star Ruby than for Webb Redblush regardless of the management system used.

**Table 1.** Effect of irrigation and soil management systems on the incidence of *Phytophthora* foot rot on Star Ruby and Webb Redblush grapefruit on sour orange rootstock.

| Factor Examined | Star Ruby | | | | | Webb Redblush | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Irrigation System[a] | | | Loosening[b] | | Irrigation System[a] | | | Loosening[b] | |
| | Drip Level | Drip Ridge | Tank-Flood | + | - | Drip Level | Drip Ridge | Tank-Flood | + | - |
| No. of trees | 240 | 240 | 96 | 480 | 96 | 240 | 239 | 72 | 459 | 92 |
| April, 1975 | | | | | | | | | | |
| % infected-scion | 4.6 | 0.0 | 3.1 | 2.1 | 4.2 | 0.4 | 0.0 | 0.0 | 0.0 | 0.1 |
| % infected-rootstock | 20.4 | 0.0 | 2.8 | 8.1 | 12.5 | 40.0 | 0.8 | 1.4 | 17.0 | 22.8 |
| June, 1975 | | | | | | | | | | |
| % infected-scion | 1.3 | 0.0 | 4.2 | 1.3 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % infected-rootstock | 1.3 | 0.8 | 2.1 | 1.3 | 1.1 | 4.2 | 0.8 | 0.0 | 2.4 | 1.1 |
| October, 1975 | | | | | | | | | | |
| % infected-scion | 1.7 | 0.4 | 2.1 | 1.3 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 |
| % infected-rootstock | 8.3 | 0.4 | 15.6 | 6.5 | 5.2 | 2.1 | 0.0 | 1.1 | 1.3 | 0.0 |
| % sites-*Phytophthora*[c] | 23.3 | 16.7 | 41.7 | 28.3 | 0.0 | 23.3 | 6.7 | 8.3 | 15.0 | 8.3 |
| No. sites sampled | 30 | 30 | 12 | 60 | 12 | 30 | 30 | 12 | 60 | 12 |
| No. of trees replaced | 53 | 5 | 3 | 47 | 14 | 8 | 2 | 0 | 9 | 1 |
| % of trees replaced | 22.1 | 2.1 | 3.1 | 9.8 | 14.6 | 3.3 | 0.8 | 0.0 | 2.2 | 1.1 |

a) Trees: 1) drip irrigated and planted on level ground; 2) drip irrigated and planted on 12-inch raised ridges; or 3) planted on level ground and tank-watered until July, 1975, and strip-flooded thereafter.

b) + = soil loosened by boring 1, 2, or 3 holes with a 24-inch diameter auger at planting time; - = soil not loosened, trees planted in a standard 8-inch diameter planting hole.

c) Percentage of sites from which *Phytophthora* was recovered on two sample dates in June and August using a calamondin bait technique.

Soil treatments affected only the incidence of disease and had no effect on the severity, i.e., the percentage of the trunk girdled once the tree was infected.

## DISCUSSION

Where trees were planted on ridges the incidence of foot rot, *Phytophthora* populations, and the number of tree replacements required was considerably less than where trees were planted on level ground. During the winter of 1974 to 1975, where drip irrigation was used without ridges, polyurethane wraps became saturated during frequent waterings and provided a favorable environment for infection. Where trees were planted on ridges, water from the drippers drained away and did not puddle at the base of the tree and saturate the wrap. On trees which were tank-watered, the wraps were wetted less frequently than with drip irrigation and the incidence of foot rot was low in the April survey. After the wraps had been removed, the incidence of foot rot was no higher under drip irrigation than under flood irrigation. Being without wraps during the summer allowed trees to dry preventing further infection and aiding in the recovery of existing lesions. With trees under flood irrigation, the presence of borders restricted surface drainage and resulted in a slightly higher foot rot incidence in the October survey.

Throughout the experiment, foot rot incidence on Star Ruby scions was greater than on Webb Redblush scions regardless of the soil management or irrigation system used. The number of replacements needed for Star Ruby trees was also greater than for Webb Redblush trees. This observation confirms the earlier finding that Star Ruby is more likely to become infected by *Phytophthora* and less likely to recover than old-line red grapefruit cultivars (7).

Loosening of soil in planting holes had relatively little effect on foot rot incidence. In the April survey incidence was slightly higher on sites where no soil loosening was performed. Loosening of the soil prior to planting may have allowed water from the drippers to soak into the soil more rapidly, thus reducing the tendency to puddle around the base of the tree and saturate the tree wrap. Recovery of *Phytophthora* from sites where no loosening was performed may have been low because samples were taken 2 ft from the base of the trunk, and the fungus may not have yet spread out through the unloosened soil to the sample sites.

On fine-textured soil, foot rot incidence and tree losses can be greatly reduced by planting trees on a raised ridge. Reduction would probably be most pronounced where the most susceptible cultivars are planted. Where drip irrigation is used, care should be taken to avoid wetting tree wraps and creating favorable conditions for foot rot infections.

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## Prevalence of Texas Citrus Mites in Certain Areas of Orange Trees

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### ABSTRACT

Over 50% of Texas citrus mites (and their eggs) was generally found in the upper area of orange trees, while about one-third occurred in the skirt area. Less than 15% of the mites (and eggs) was found on leaves in the inside area of the tree. Improved spray patterns for better coverage on leaves in the upper portion of citrus trees are suggested to provide better control of this mite.

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The Texas citrus mite, *Eutetranychus banksi* McG., has been considered an economic pest of citrus in the State for many years. Trees with heavy mite infestations have been observed to partially defoliate following drying winds, particularly during the fall. Loss of leaves was more noticeable in the top portion of the trees. This investigation was initiated in 1969 to determine the possible differences in numbers of Texas citrus mites on leaves in certain areas of the trees.

Although this mite feeds predominately on leaves, it will also feed on fruit. Previous investigations showed that Texas citrus mite populations were greater during May to July than at other times of the year (1). These mites were also found in greater numbers in the south quadrants of the tree during most months of the year (2). The airblast sprayer provided rather uniform oil deposit in the top, skirt, and inside areas of grapefruit trees, while a concentrate sprayer gave greater oil deposit in the skirt area of the tree (3).

### METHODS

Texas citrus mite populations were sampled on orange trees (8 to 12 ft in height) at the Texas Agricultural Experiment Station at Weslaco at three different areas on the trees: 5 to 7 ft above the ground; 1 to 2 ft above the ground; and 1 ft or more inside the tree at 3 to 6 ft above the ground. Two leaves were sampled in each quadrant of five trees. Four sets of five trees each constituted the four replications. The third leaf from the apical end of the most recent mature flush was sampled varying to the second or fourth as necessary.

Mites and their eggs were counted under magnification after being removed from each 40-leaf sample with a standard mite-brushing machine. The mites were counted on one-half the area of the disk pattern.

Pesticides were applied uniformly. Dicofol (Kelthane® ) was used almost exclusively.

## RESULTS AND DISCUSSION

Texas citrus mites were more numerous on leaves in the upper areas of orange trees than in the skirt or inside areas (Table 1). Average differences greater than 20% were found between upper-skirt and skirt-inside areas during the first 3 years when greater numbers of mites were found and sampling dates were more numerous. During the following 4 years when fewer mites were counted, the average percentage of mites in the upper area of the tree decreased while the average percentage of mites increased in the skirt and inside areas of the tree. This decrease may be explained in part by the smaller number of samples taken during periods when mites increased to greater levels and possibly better control was obtained by pesticidal applications. Over 50% of the total number of mites counted during the 7 years was found in the upper areas of the trees. Less than 15% of the mites occurred in the inner area of the trees.

The percentages of mites and eggs found in each of the three areas of the tree varied within 1.6% during the first 3 years (Tables 1, 2). Of the total number of eggs counted in the various areas of the trees over the 7-year span, less than 28% of the eggs were recorded in samples during the last 4 years. The percentages of the total number of eggs counted in the last 4 years are shown from the indicated areas of the trees: 43.0—upper, 39.2—skirt, and 17.8—inside. The comparative percentages of eggs in the respective areas of the trees during the first 3 years were: 53.5- -upper, 34.0—skirt, and 12.4—inside.

The 2-month periods in which larger populations of mites occurred were: February to March, July to August, and October to November. No inference is made that these periods are normal for this area as treatment schedules differed from those generally followed. Over 99% of the mites and eggs found in the counts during the February to March period of the 7 years were counted from samples taken during 1969, 1970, and 1971. During the first 3 years, the percentages of Texas citrus mites in the upper area of the trees were 5.5 and 7.9% greater during the October to November and July to August periods, respectively, than in the February to March period. More mites tended to be in the inside area of the trees during the February to March period than during the other 2-month periods. Mite eggs during the February to March period were 6.0 and 6.1% more numerous on inside leaves than eggs found in the same area during the October to November and July to August periods, respectively. The percentages of mites and eggs tended to be smaller in the upper area of the trees during the February to March period than during the other 2-month periods.

The reduced amount of leaf flushes in the inside area of the tree and the presence of a greater percentage of older leaves may explain why fewer Texas citrus mites and eggs are found in that area of the tree. The greater numbers of mites in the upper area of the tree are suggestive that greater effort should be placed on pesticidal coverage of leaves in this area for control. However, this does not infer that coverage is not important on the inside leaves.

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**Table 1.** Distribution of Texas citrus mite on leaves within orange trees, 1969 to 1975.

| Year | Mites total | Count dates no. | Percent mites in indicated area of tree | | |
|---|---|---|---|---|---|
| | | | upper | skirt | inside |
| 1969 | 32,357 | 28 | 52.6 | 35.2 | 12.2 |
| 1970 | 17,170 | 31 | 58.5 | 33.4 | 8.1 |
| 1971 | 18,868 | 29 | 53.2 | 29.9 | 16.9 |
| 1972 | 9,483 | 24 | 51.8 | 35.3 | 12.9 |
| 1973 | 396 | 14 | 48.5 | 38.1 | 13.4 |
| 1974 | 2,410 | 17 | 42.1 | 34.3 | 23.6 |
| 1975 | 809 | 14 | 45.1 | 40.9 | 14.0 |
| Total | 81,493 | 157 | | | |
| Mean[1] | | | 53.5 | 33.6 | 12.9 |

[1]Derived from 7-year total figures.

SOURCE: Texas Agricultural Experiment Station at Weslaco.

**Table 2.** Distribution of Texas citrus mite eggs on leaves within orange trees, 1969 to 1975.

| Year | Eggs total | Count dates no. | Percent mite eggs in indicated area of tree | | |
|---|---|---|---|---|---|
| | | | upper | skirt | inside |
| 1969 | 35,302 | 28 | 51.6 | 36.6 | 11.8 |
| 1970 | 18,857 | 31 | 58.4 | 33.7 | 7.9 |
| 1971 | 17,540 | 29 | 52.2 | 29.3 | 18.5 |
| 1972 | 10,522 | 24 | 46.6 | 38.6 | 14.8 |
| 1973 | 481 | 14 | 56.1 | 29.7 | 14.2 |
| 1974 | 3,881 | 17 | 33.8 | 41.9 | 24.3 |
| 1975 | 802 | 14 | 32.4 | 39.3 | 28.3 |
| Total | 87,385 | 157 | | | |
| Mean[1] | | | 51.6 | 35.0 | 13.4 |

[1] Derived from 7-year total figures.

SOURCE: Texas Agricultural Experiment Station at Weslaco.

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**Aerial Application for Rust Mite Control on Texas Citrus**

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**ABSTRACT**

Acaricides applied by fixed-wing aircraft to Valencia orange trees provided effective control of citrus rust mite, *Phyllocoptruta oleivora* (Ashmead). Four pt of Acaraben® 4E (2 lb ai chlorobenzilate) and 2 gal citrus oil spray (Orchex 796) applied in 10 gal total spray per acre gave mite control to 8 weeks post-treatment. Reasonably good control was obtained with rates as low as 2 and 3 pt of Acaraben per acre. Three gal of Kelthane® EC (4.8 lb ai dicofol) and 1 gal oil spray in 10 gal spray/acre controlled rust mite but caused necrotic spotting of foliage. One gal Kelthane (1.6 lb ai dicofol) + 1 gal oil spray failed to give control.

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Citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), is the principle pest of citrus in the Lower Rio Grande Valley of Texas. Most citrus growers follow a preventative rust mite control program and include an acaricide in each of 3 to 4 annual sprays. Virtually all of the acreage is sprayed by ground application equipment. Following periods of high rainfall it is difficult for ground equipment to re-enter the orchard. Wet, humid conditions and high temperatures (above 80 F) are ideal for rust mite development, thus increasing the potential for rust mite damage.

High rainfall occurred in most parts of the Valley from mid-July to early September 1975, with 17.3 inches recorded at the Texas A&I University Citrus Center, Weslaco. Many orchards, particularly those on fine-textured soils, could not be entered with spray equipment for nearly 2 months. Where the mid-summer spray was delayed, some orchards did not receive an acaricide treatment for almost 3 months, resulting in severe late summer russeting of fruit.

Numerous growers expressed interest in aerial application as an alternative or supplement to ground application of acaricides. Since effective rust mite control has been achieved in Florida by aerial sprays (3, 4, 5), cooperative aerial application experiments between Texas A&I University Citrus Center and Rio Farms Inc. were conducted during late summer and fall, 1975. The results of these experiments are reported herein.

## METHODS AND MATERIALS

*Preliminary Aerial Application Trials* - A preliminary aerial application experiment at Rio Farms in Monte Alto, Texas was initiated on 3 September 1975, on a 50 acre block of 20-year-old Valencia orange trees [*Citrus sinensis* L. (Osbeck)] heavily infested with rust mite. A pre-spray count showed 47% of a 200-leaf sample, randomly gathered from the test block, infested with rust mite.

Four pt of Acaraben® 4E (2 lb ai chlorobenzilate) and 2 gal petroleum spray oil (Orchex 796) were mixed with water to a volume of 10 gal (rate per acre) and applied by a Rockwell Thrush Commander aircraft. Spacing in the citrus planting was 15 x 25 ft and the aircraft flew all middles between rows.

The aircraft was equipped with a 40-ft spray boom located 9 inches below and 6 inches behind the trailing edge of the wing. Thirty spray TeeJet® nozzles with TG-3 full cone tips (Spraying Systems Co., Wheaton, Illinois) were spaced along the boom at intervals, varying from 6 to 17 inches. Boom pressure during operation was 60 psi. Plane speed at each pass over the orchard was 115 mph with the boom about 4 to 6 ft above the tree tops. Application commenced at 2 hr before sunset with the following conditions: 50% relative humidity, 81 F, and winds 2 mph from the southeast.

Following the aerial application on 3 September, rust mite populations in the Acaraben treated block and an untreated block of Valencia oranges were monitored at about 2 week intervals to 8 weeks post-treatment.

*Comparison of Chlorobenzilate and Dicofol Applied by Air* - In a second experiment, initiated on 11 September, two rates of Acaraben and two rates of dicofol (Kelthane® ) applied by air were compared for rust mite control. Rates tested are given in Table 1. Each rate was combined with 1 gal of citrus oil spray and applied to 10 gal total spray mix per acre. Treatments were applied to separate blocks of mature Valencia orange trees. Each treatment block was about 12 acres.

The aircraft used was a Grumman Ag. Cat. model G, with a 25.5 ft boom located 6 inches aft of the lower wing. Thirty TeeJet® nozzles with TK10 Floodjet tips (Spraying Systems Co., Wheaton, Illinois) were spaced at 3 to 12 inch intervals along the boom length. Boom pressure during operation was 80 psi. The aircraft flew all middles between rows (15x25 ft tree spacing) at 90 mph.

All applications were made between dawn and 10:00 A.M. Winds were less than 4 mph from the southeast; temperature was 74 F and relative humidity was 85%, with heavy dew on foliage at the time spraying commenced.

Pre- and post-treatment counts of citrus rust mite were made by taking a 200 to 300 leaf sample randomly from trees in each test block at each counting date. Leaf samples were taken to the laboratory and examined for rust mite under a binocular microscope. A leaf was rated as infested if any live mites were found.

## RESULTS

*Preliminary Aerial Application* - Reduction in rust mite populations in the aerially treated block was rapid and dramatic, i.e., from a 47% pre-spray leaf infestation level to 1% at the one week post-spray (Fig. 1). The percent of infested leaves in the untreated control increased from 52 to 84% during the 8 week monitoring period. The combination of 4 pt Acaraben 4E and 2 gal citrus oil spray applied by air provided effective, residual rust mite control.

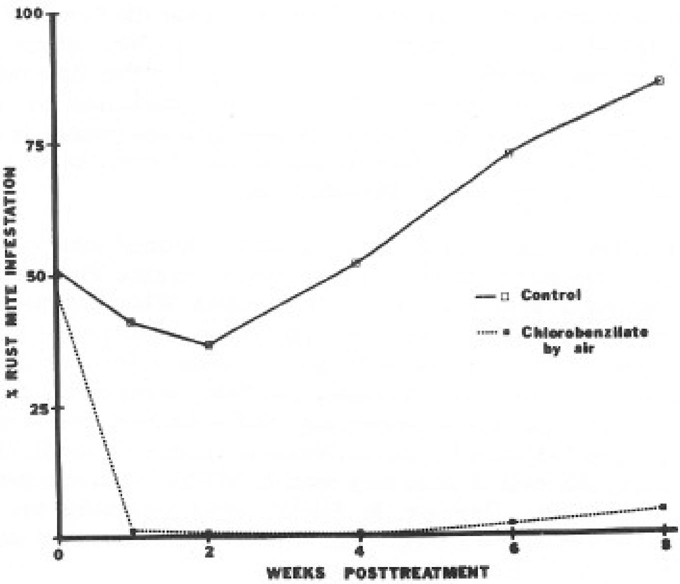


**Fig. 1.** Citrus rust mite control on Valencia orange trees sprayed by air with 2 lb ai Chlorobenzilate + 2 gal citrus oil spray and applied at 10 gal total spray per acre.

*Comparison of Acaricides Applied by Air* - Results of experiments comparing different rates of Acaraben and Kelthane applied by air are given in Table 1. All treatments except the low rate of Kelthane (1.6 lb ai dicofol/acre) controlled rust mite. Little difference was seen between control obtained with 2 and 3 pt of Acaraben, but the pre-spray infestations in the block receiving the 3 pt of Acaraben were almost three-fold higher. As a general rule, if 10% or more of the leaves are infested with rust mite an acaricide application is usually recommended.

A phytotoxic reaction was observed on foliage in the test block of Valencia orange trees sprayed with the 3 gal Kelthane — 1 gal citrus oil spray combination. About 2% of the leaves had necrotic spots, 1 to 6 mm in diameter, on the upper and lower leaf surfaces. Phytotoxicity was not observed in any other blocks receiving acaricide treatments.

## DISCUSSION

Results of the current investigations show that effective rust mite control can be achieved by aerial application of either chlorobenzilate or dicofol. Aerial spraying could benefit Texas citrus growers, particularly when wet conditions preclude use of ground spray equipment. The most limiting factor to attaining rust mite control by this method is the almost continuous southeasterly wind that buffets the Lower Rio Grande Valley. Wind gusts of 20 to 25 mph are common, and while wind affects spray distribution and coverage with any method of application, its effects on aircraft spraying are greater. Most favorable conditions for aerial application usually occur during the early morning hours (sunrise to about 10:00 A.M.) and 1 to 2 hr prior to sunset. Aerial spraying should be terminated when wind velocity exceeds 5 mph.

Whether aerial application can be used to control other pests on Valley citrus remains to be investigated. Texas citrus mite, *Eutetranychus banksi* McGregor, appears to be a likely candidate. While not specifically monitored in these trials, very few Texas citrus mites were observed, especially in dicofol-treated trees. Texas citrus mites thrive under hot, dry conditions and are not nearly as damaging to Valley citrus as rust mites. It is doubtful that armored scale insects, e.g., chaff scale, *Parlatoria pergandii* (Comstock), or California red scale, *Aonidiella aurantii* (Maskell), can be controlled by this method, since they normally inhabit the interior portions of the tree canopy. However, in Florida aerial application has been successful for the control of Black scale, *Saissetia olea* (Bernard) (1), and the spirea aphid, *Aphis spiraecola* Patch (2).

The phytotoxicity observed on foliage of trees receiving the 3-gal rate of Kelthane plus 1 gal of citrus oil spray was probably due to the high level of organic solvents or carrier in the spray mix. Of the 10 gal total spray

**Table 1.** Percent infestation by citrus rust mite on Valencia orange trees treated by air with different rates of acaricides.

| Treatment and Rate per Acre[2] | | PERCENT RUST MITE INFESTATION[1] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Weeks After Treatment: | | | | | |
| | | Pre Treatment | +2 | +3 | +4 | +5 | +7 | +9 |
| Chlorobenzilate[3] | 2 pt | 27 | 2 | 4 | 3 | 0 | 7 | 0 |
| Chlorobenzilate | 3 pt | 76 | 2 | 0 | 0 | 1 | 0 | 1 |
| Dicofol[4] | 1 gal | 59 | 18 | 37 | 26 | 30 | 37 | 41 |
| Dicofol | 3 gal | 45 | 2 | 0 | 0 | 0 | 0 | 1 |
| Untreated Control | ------ | 52 | 34 | 46 | 52 | 63 | 73 | 80 |

1 At each count 200 leaves were examined from each treatment block; a leaf was considered infested if any living mites were observed.

2 10 gal total spray per acre (indicated rate + 1 gal spray oil + water).

3 Applied as Acaraben® 4E (4 lb ai/gal).

4 Applied as Kelthane® EC (1.6 lb ai/gal).

applied per acre, 40% was dicofol, carrier, and oil. The phytotoxicity can probably best be remedied by using a formulation containing a higher percentage of dicofol, viz. Kelthane MF (4 lb ai per gal). This would permit application of the required amount of active dicofol in considerably less organic solvent.

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## Citrus Blackfly (Hemiptera: Aleyrodidae), Feeding Injury and Its Influence on the Spectral Properties of Citrus Foliage

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### ABSTRACT

The injury to citrus leaves caused by the feeding of the citrus blackfly, *Aleurocanthus woglumi* Ashby, resulted in damage to cells of the lower epidermis, that is, thickened cell walls, loss of cellular contents, and the appearance of chlorotic areas. The spectral properties of the leaves, reflectance, transmittance, and absorptance, were all significantly different in the visible region (500 to 750 nm) of the spectrum from those of healthy leaves.

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Damage to citrus foliage caused by the citrus blackfly, *Aleurocanthus woglumi* Ashby, is of two types—actual feeding injury and the physiological damage caused by a sooty-mold fungus. *Capnodium citri* Berk. and Desm., that develops on the honeydew excreted by the developing insect. When the sooty-mold deposits become heavy, they reduce the photosynthesis and respiration of the affected plant. The extent of the damage to the foliage from the feeding injury is more difficult to determine, but it is considered significant. Color infrared aerial photography has been used to detect the presence of the sooty-mold deposits caused by insect activity on citrus foliage (4, 5) but the nature of the feeding injury and its effects on the spectral properties of the foliage have not been determined. The present paper reports the results obtained in studies made to determine the effects of the feeding injury by the blackfly to the citrus leaf structure, and the influence of this damage on the reflectance characteristics of citrus foliage.

### MATERIALS AND METHODS

Ten orange leaves were randomly selected, five damaged by the feeding injury of the citrus blackfly and five apparently undamaged. The leaves were immediately wrapped in plastic to limit dehydration, and before the spectrophotometric measurements were made, they were wiped with dampened paper towels to remove any surface contamination.

The spectrophotometric measurements were made with a Beckman Model DK-2A® spectrophotometer equipped with a reflectance attachment (3). (Company and trade names are included for the benefit of the reader and do not imply an endorsement of or preference for the product listed by the U.S. Department of Agriculture.) The basic design of this instrument allows the placement of a beam of monochromatic light of a desired wavelength upon a leaf. This reflected or transmitted light is collected by an integrating sphere, and the intensity is measured by a photoelectric cell. The integrating sphere is coated with a nearly perfect diffusive reflector of light. When an elementary area of the sphere is illuminated, the diffusing material reflects the light equally to all other parts of the sphere surface. A detector in the sphere surface measures the amount of light being reflected in the sphere. Thus diffuse reflectance and transmittance of upper (adaxial) and lower (abaxial) leaf surfaces over the 500- to 2,500-nm wavelength interval (WLI) could be measured.

All data were corrected for decay of the $BaSO_4$ standard to produce absolute radiometric values (1). Absorptance was calculated as: 100-(percentage reflectance + percentage transmittance). Leaf thickness was measured with a linear displacement transducer and digital voltmeter (6) and leaf area was determined with a planimeter. Percentage water content of the leaves was determined on an oven-dry weight basis by drying them at 68°C for 72 h and then cooling them in a desiccator before the final weighing.

## RESULTS AND DISCUSSION

Tissue pieces for study were taken near the center of leaves about 1 cm from the midrib. Samples were fixed in formalin-acetic acid-alcohol (FAA), and dehydrated with tertiary butanol, embedded in paraffin, stained with safranin-fast green (7), microtomed at a thickness of 10 um, and photographed with a Zeiss Standard Universal® Photomicroscope.

Fig. 1 shows transverse sections of an undamaged orange leaf (upper photomicrograph) and an orange leaf damaged by blackflies (lower photomicrograph) with damaged cells in the area of the lower epidermis. The cellular contents of many cells appear to be gone, and the cell walls are greatly thickened. The damaged leaf areas were also chlorotic. The only significant effect of damage occurred in the visible region (500 to 750) of the 500- to 2,500-nm WLI. Hence, the measurements in this region were analyzed statistically (8).

Tables 1 and 2 report the measured reflectance, transmittance, and absorptance for the upper and lower leaf surfaces, respectively. The differences between the lower leaf surfaces of undamaged and damaged leaves were about similar to the differences between the upper leaf surfaces of undamaged and damaged leaves. Damaged leaves had significantly higher reflectance and transmittance from the upper leaf surfaces than undamaged leaves. Absorptance values were significantly higher for undamaged leaves. Also, all mean comparisons (2) were significant for reflectance, but the average values for the 500-and 600-nm wavelengths for transmittance and absorptance were statistically alike.

The lower leaf surfaces of damaged leaves likewise had significantly higher reflectance and transmittance than those of undamaged, and again, the absorptance values were significantly higher for undamaged leaves. However, for lower leaf surfaces, all means were statistically different except for the mean values for the 500- and 600-nm wavelength.

Table 3 reports the data for leaf thicknesses and percentage water content of damaged and undamaged orange leaves. Obviously, the feeding of blackflies had little effect on the thicknesses and water content of orange leaves.

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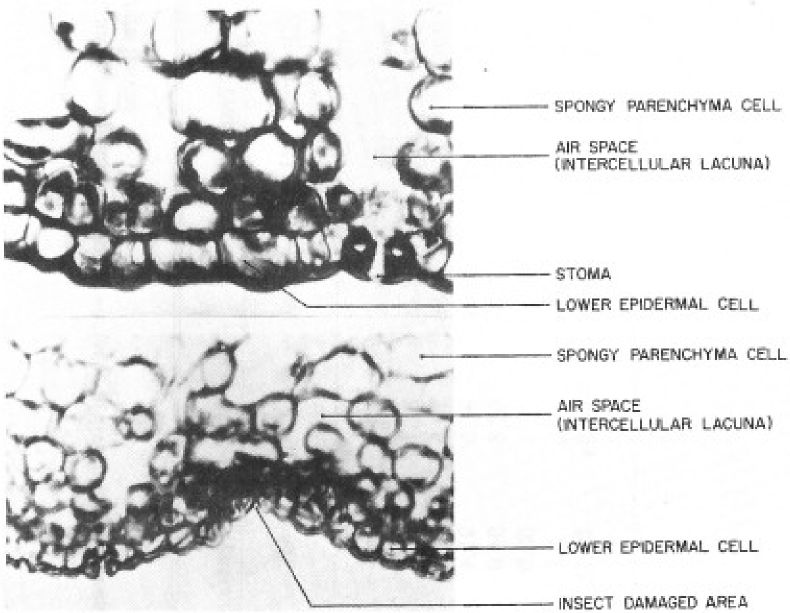


**Fig. 1.** Transverse sections (515X) of orange leaves showing normal leaf (upper photomicrograph) and leaf damaged by blackflies (lower photomicrograph).

**Table 1.** Average values for reflectance, transmittance, and absorptance of upper surfaces of five orange leaves damaged by blackflies (D) and five undamaged (U) orange leaves.

| Wave- | Reflectance | | | Transmittance | | | Absorptance | | |
|---|---|---|---|---|---|---|---|---|---|
| length | D | U | Mean[a] | D | U | Mean[a] | D | U | Mean[a] |
| nm | % | % | % | % | % | % | % | % | % |
| 500 | 9.5 | 8.0 | 8.8a | 2.8 | 2.0 | 2.4a | 87.7 | 90.0 | 88.9a |
| 550 | 13.5 | 10.8 | 12.2b | 7.0 | 5.6 | 6.3b | 79.5 | 83.6 | 81.6b |
| 600 | 8.7 | 6.9 | 7.8c | 2.8 | 1.7 | 2.3a | 88.5 | 91.4 | 90.0a |
| 650 | 6.2 | 5.4 | 5.8d | 0.7 | 0.5 | 0.6c | 92.6 | 94.0 | 93.3c |
| 700 | 31.3 | 27.3 | 29.3e | 22.3 | 20.2 | 21.3d | 46.4 | 52.6 | 49.5d |
| 750 | 55.5 | 55.1 | 55.3f | 41.5 | 41.8 | 41.7e | 3.0 | 3.1 | 3.1e |
| Mean | 20.8a | 18.9b | | 12.8a | 12.0b | | 66.3a | 69.1b | |

[a] Means followed by common letters are statistically alike, P = 0.05.

**Table 2.** Average values for reflectance, transmittance, and absorptance of lower surfaces of five orange leaves damaged by blackflies (D) and five undamaged (U) orange leaves.

| Wave- | Reflectance | | | Transmittance | | | Absorptance | | |
|---|---|---|---|---|---|---|---|---|---|
| length | D | U | Mean[a] | D | U | Mean[a] | D | U | Mean[a] |
| nm | % | % | % | % | % | % | % | % | % |
| 500 | 16.3 | 14.5 | 15.4a | 2.9 | 2.1 | 2.5a | 80.7 | 83.4 | 82.1a |
| 550 | 22.4 | 20.2 | 21.3b | 7.4 | 5.9 | 6.7b | 70.2 | 73.8 | 72.0b |
| 600 | 16.9 | 14.0 | 15.4a | 3.0 | 2.0 | 2.5a | 80.1 | 84.0 | 82.1a |
| 650 | 11.1 | 8.8 | 10.0c | 0.6 | 0.6 | 0.6c | 88.2 | 90.6 | 89.4c |
| 700 | 36.6 | 33.8 | 35.2d | 23.4 | 20.7 | 22.1d | 40.0 | 45.5 | 42.8d |
| 750 | 52.5 | 53.5 | 53.0e | 44.0 | 43.1 | 43.6e | 3.5 | 3.4 | 3.5e |
| Mean | 26.0a | 24.1b | | 13.6a | 12.4b | | 60.5a | 63.5b | |

[a] Means followed by common letters are statistically alike, P = 0.05.

**Table 3.** Thicknesses and water content of undamaged orange leaves and those damaged by citrus blackflies.

| | Thickness | | Water content | |
|---|---|---|---|---|
| Leaf No. | Damaged Leaf | Undamaged Leaf | Damaged Leaf | Undamaged Leaf |
| | mm | mm | % | % |
| 1 | 0.176 | 0.185 | 52.2 | 52.5 |
| 2 | .183 | .174 | 59.2 | 59.2 |
| 3 | .189 | .208 | 51.4 | 51.9 |
| 4 | .171 | .178 | 57.6 | 59.6 |
| 5 | .186 | .186 | 52.7 | 49.1 |
| Mean | .181 | .186 | 54.7 | 54.5 |
| Standard error | .003 | .116 | 1.6 | 2.1 |

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**Wood Boring Beetles Inhabiting Citrus in the Lower Rio Grande Valley of Texas**

**Part I: Cerambycidae**

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## ABSTRACT

Thirteen species of Cerambycidae are recorded living in citrus in the Lower Rio Grande Valley of Texas. Citrus is a new host record for eight of the species. Identifying characteristics are given for each species together with brief notes on biology.

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Little attention has been given the wood boring beetles attacking citrus in the Lower Rio Grande Valley of Texas. Dean (2) previously recorded four species of round-headed borers from Valley citrus. While not considered major pests, the wood borers can cause economic damage, principally to citrus trees already weakened by mechanical and freeze injury and/or disease. Borers usually live and tunnel in dead wood but some species once established will move into the living parts of the tree (3). Such attacks can reduce tree vigor and contribute to an overall degeneration which eventually necessitates the tree's removal and replacement.

The objective of the present investigation was to identify the wood boring beetles associated with citrus in South Texas.

## MATERIALS AND METHODS

Citrus wood [grapefruit, *Citrus paradisi* Macf. and sweet orange, *Citrus sinensis* L. (Osbeck)] which showed wood borer activity was gathered during an 18-month period (Sept. 1974 to Mar. 1976) at Texas A&I University, Weslaco and Rio Farms, Inc., Monte Alto, Texas.

One to 6-inch diameter pieces of wood cut from dead branches on living trees, still-standing dead trees, or citrus brush piles were placed in screened rearing cages and observed weekly for emerging wood borers.

Species identifications were made by the authors and/or Drs. G. N. Nelson and E. Gorton Linsley (see acknowledgement).

## RESULTS

During the present study 9 species of cerambycidae, in addition to those recorded by Dean (2), were reared from citrus wood: *Gnaphalodes trachyderoides* Thomson, *Placosternus difficilis* (Chevrolat), *Neoclytus acuminatus hesperus* Linsley, *Neoclytus augusti* (Chevrolat), *Obrium maculatum* (Olivier), *Euderces reichei exilis* Casey, *Anelaphus inermis* (Newman), *Phopalophora angustata* Schaeffer, and *Phopalophora laevicollis* (LeConte). Citrus is a new host record for all these species except *Anelaphus inermis* (Newman).

Many of the cerambycid borers have a general host preference. *Gracilia minuta* (Fabricius), *Elaphidionoides villosus* (Fabricius), *Oncideres cingulator* Say, and *Dendrobias mandibularis mandibularis* Audinet-Serville have been collected in South Texas on hosts other than citrus. However, these species have been shown to inhabit citrus in other regions (3).

## ANNOTATED LIST OF CERAMBYCIDAE OF CITRUS

*Archodontes melanopus serrulatus* (LeConte)

Characteristics: Moderately elongate, uniformly dark brown. Sides of pronotum dentate or crenulate. Length 21 to 60 mm.

Comments: This species is very similar in appearance to *Stenodontes dasytomus* (Say). A. *melanopus* is characterized by obtuse antennal tubercles and nearly vertical mandibles, while in S. *dasytomus* the antennal tubercles are acute and the mandibles nearly horizontal. Adults are active from June to September.

*Stenodontes dasytomus* (Say) Fig. 1.

Characteristics: Moderately elongate and flattened dorsally. Sides of pronotum dentate or crenulate. Uniformly dark brown to blackish. Length 23 to 47 mm.

Comments: This species and *Archodontes melanopus serrulatus* differ from other citrus boring beetles in size and color. Horizontal mandibles and acute antennal tubercles separate it from *A. melanopus*. Larvae feed gregariously in a variety of hardwood hosts from northern Mexico to the southern United States. They prefer the heartwood, particularly near the base of the tree (1). Under severe attacks the entire trunk may be honeycombed. Adults are active from June to September.

*Gracilia minuta* (Fabricius)

Characteristics: Slender, uniformly brown. Elytra surface finely clothed with pubescence. Length 4 to 6 mm.

Comments: This is an introduced species from Europe that lives in a large variety of hardwood hosts. Adults are active from May to July.

*Eburia mutica* LeConte Fig. 1.

Characteristics: Elongate and differs from other citrus borers by the presence of polished ivory colored spots on the elytra. Dorsal surface brown, pubescence uniform and dense but not obsuring the surface. Dorsal surface of pronotum with two prominent calli in front of middle. Length 12 to 22 mm.

Comments: Adults have been collected from under the bark and cut from dead citrus wood. Adults are active from May to September.

*Gnaphalodes trachyderoides* Thomson Fig. 1.

Characteristics: Robust, integument brown. Pronotum densely clothed with white pubescence obscuring the surface. Elytra surface pubescent but not obscured, pubescence has a slightly mottled appearance; apices bispinose. Length 17 to 24 mm.

Comments: NEW HOST RECORD: Adults appear to be active most of the year in the Lower Rio Grande Valley of Texas. Specimens emerged from February through September. This species is found throughout Central America where it lives in a variety of native hosts. The Lower Rio Grande Valley of Texas appears to be the northern limit of its range.

*Placosternus difficilis* (Chevrolat) Fig. 1.

Characteristics: Moderately elongate, tapering; integument black; legs, antennae and mouth parts reddish; pubescence short, black and yellow. Dorsal surface with black pubescence interrupted with dense yellow markings. Pronotum with four narrow transverse bands. Elytra with a transverse band near the base, an undulating W-shaped line in the sub-basal area; broken lines in median, post median, and sub-apical regions. Length 12 to 17 mm.

Comments: NEW HOST RECORD: Adults appear to be active all year in the Lower Rio Grande Valley. Adults emerged from citrus wood between October 1975 and February 1976.

*Dendrobias mandibularis mandibularis* Audinet-Serville

Characteristics: Moderately robust, slightly convex dorsally. Head and pronotum black, shiny, and glabrous. Pronotum with acute lateral tubercles. Elytra yellow with base black, usually with a medial black transverse band which divides the yellow more or less equally, suture and lateral margins black. Length 17 to 23 mm.

Comments: Adults are active from March to November. Larvae live in dead branches (7).

*Enaphalodes taeniatus* (LeConte) Fig. 2.

Characteristics: Elongate, subcylindrical, dark brown, flecked with whitish pubescence. Elytra with a large whitish irregularly shaped blotch or broad transverse band at or anterior to the middle; densely, coarsely punctate anteriorly becoming less punctate posteriorly. Length 19 to 28 mm.

Comments: E. *taeniatus* (LeConte) = *Romaleum taeniatum* LeConte (2). Adults are active from April to September.

*Elaphidionoides villosus* (Fabricius)

Characteristics: Elongate, moderately slender. Dorsal surface brown with pale-yellowish pubescence forming small scattered patches, producing a variegated appearance. Length 12 to 17 mm.

Comments: Larvae cut living twigs from a large variety of hardwood hosts including citrus. Craighead (1) states that the eggs are laid near the tip of the host twig in the axil of the leaves. In the late summer the larvae mine down the stem and cut the branch from inside leaving only the bark holding the branch to the tree. The weakened branch eventually falls from the tree and the larvae pupate within. Adults are active from March to July.

*Anelaphus inermis* (Newman)

Characteristics: Slender, subcylindrical, integument reddish-brown to brown. Dorsal surface mottled irregularly with pale-grayish pubescence forming small patches of dense patterns. Elytra apices bispinose, outer spine slightly longer. Length 10 to 18 mm.

Comments: The untrimmed ends of carelessly pruned citrus branches attract ovipositing females (3). The young larvae remain inside and hollow out the dead ends, then descend into the living parts of the branch. Adults are active from February to June.

*Obrium maculatum* (Olivier) Fig. 2.

Characteristics: Moderately elongate, flattened. Dorsal surface testaceous, variegated with brown, and shiny. Pronotum narrowed at base and apex. Elytra markings variable but usually consisting of a transverse sinuate basal line; two V-shaped marks, one just before and one just behind middle and a transverse distal line. Length 4 to 7 mm.

Comments: NEW HOST RECORD: Adults have been recorded from a large variety of hosts throughout eastern North America and northern Mexico. Adults are active from March to October.

*Neoclytus acuminatus hesperus* Linsley

Characteristics: Elongate, slender, cylindrical; uniformly reddish-brown. Elytra with four transverse yellow bands, second and third bands ascending toward suture of elytra. Length 6 to 18 mm.

Comments: NEW HOST RECORD: Adults are active from February to October in South Texas.

*Neoclytus augusti* (Chevrolat)

Characteristics: Elongate, tapering, integument reddish-brown. Pronotum with pale-yellowish pubescence, disk with a longitudinal medial row of transverse carina. Elytra marked with three areas of heavy pale yellow pubescence: a wide transverse band at base forming a half circle posteriorly, a second narrow transverse band at middle forming an oblique "M", and a third transverse band apically tapering anteriorly toward suture of elytra. Length 8 to 14 mm.

Comments: The emergence of this species from citrus during August of 1975 was the first collection of this insect from the United States (10).

*Euderces reichei exilis* Casey Fig. 2.

Characteristics: Elongate, slightly cylindrical. Elytra with a transverse elevated ivory band at middle. Color reddish-brown in front of ivory band and black posterior to band. Pronotum reddish-brown and constricted at base. Length 4 to 6 mm.

Comments: NEW HOST RECORD: In general appearance these beetles resemble ants and are often found in company with them. Adults are active from March to June.

*Rhopalophora angustata* Schaeffer

Characteristics: Elongate, slender. Head and pronotum red, elytra rufopiceous. Pronotum with a longitudinal strip of grayish pubescence along each side dorsally and a lateral strip extending ventrally. Elytra densely clothed with grayish pubescence obscuring the surface. *Rhopalophora* differs from other citrus-inhabiting cerambycids by having the distal end of the femur enlarged. Length 6 to 10 mm.

Comments: NEW HOST RECORD: This species was originally described from Brownsville, Texas. Adults are active from March to September.

*Rhopalophora laevicollis* (LeConte) Fig. 2.

Characteristics: Elongate, slender, flattened dorsally. Dorsal surface bicolored; head black, pronotum rufous, with a blackish elongate median mark. Elytra rufopiceous densely clothed with smokey pubescence that obscures the surface. Distal end of the femur enlarged. Length 8 to 12 mm.

Comments: NEW HOST RECORD: Adults are active throughout the summer months from April to November.

*Oncideres cingulator* Say

Characteristics: Elongate, moderately cylindrical; integument dark brown. Pronotum densely clothed with creamy white pubescence obscuring surface. Elytra also densely clothed with creamy white pubescence but variegated with small patches of orange; two wide brownish transverse bands, one basal and a sinuate band behind middle. Length 13 to 18 mm.

Comments: This species severs twigs and small branches from living trees. Damage is similar to that of *Elaphidionoides villosus,* but larvae of *E. villosus* cut branches from the inside while the adults of *O. cingulator* girdle external. Adults are active from June to October.

## SUMMARY

Thirteen species of cerambycidae have been reared from citrus wood collected in the Lower Rio Grande Valley of Texas. Four of these species were previously recorded by Dean, 1953. In the present study, nine more species were identified, with citrus a new host record for eight of these. Investigations are continuing and additional species of wood boring beetles will undoubtedly be found inhabiting *Citrus* spp.

## ACKNOWLEDGEMENT

The authors thank Dr. H. R. Burke (Texas A&M University, College Station) for the use of specimens in the Texas A&M University Collection. Gratitude is also expressed to Dr. G. H. Nelson (Kansas City College of Osteopathic Medicine, Kansas City, Mo.) and Dr. E. Gorton Linsley (University of California, Berkeley) for help with cerambycid identifications.

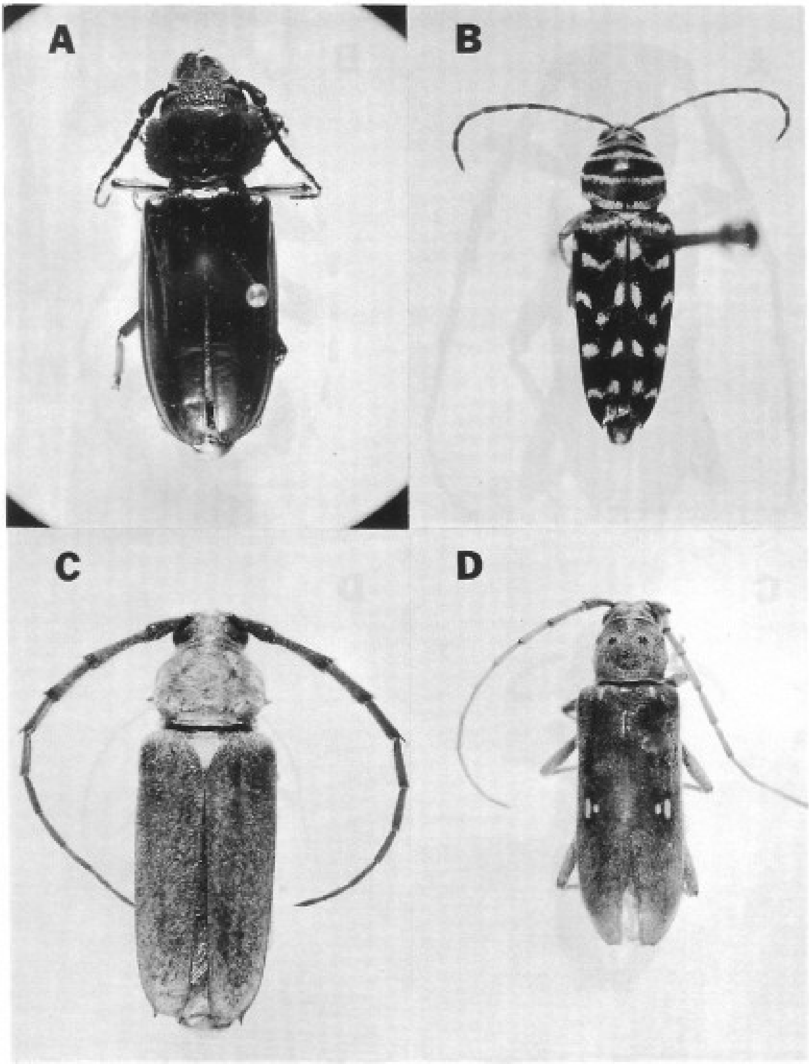


**Fig. 1.** A) *Stenodonotes dasytomus* (Say), B) *Placosternus difficilis* (Chevrolat), C) *Gnaphalodes trachyderoides* Thomson, and D) *Eburia mutica* LeConte.

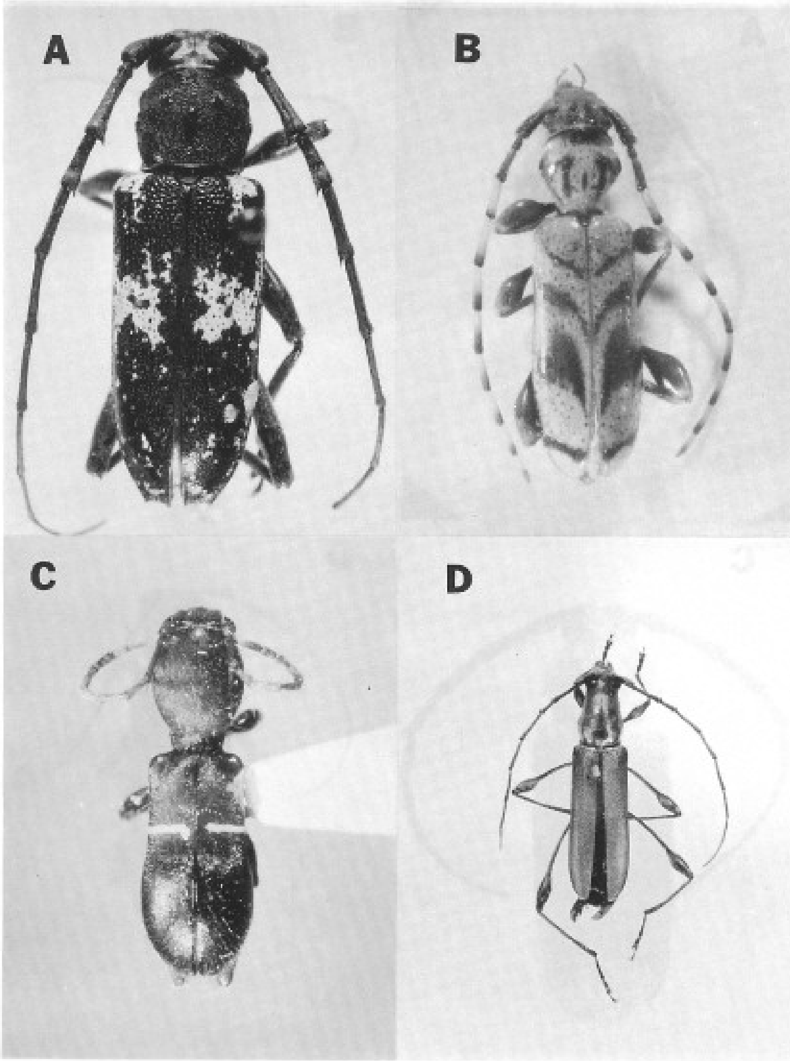


**Fig. 2.** A) ***Enaphalodes taeniatus*** (LeConte), B) ***Obrium maculatum*** (Olivier), C) ***Euderces reichei exilis*** Casey, and D) ***Rhopalophora laevicollis*** (LeConte).

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## Status of the Star Ruby Grapefruit, 1976

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### ABSTRACT

Some 5 years of data and observations primarily taken on test plots of Star Ruby and Ruby Red grapefruit are summarized. In tree growth and yields, the two varieties are comparable, though there is considerable variation due to orchard, season, and nucellar influences. Star Ruby trees become yellow and chlorotic in appearance under stress of cold or certain herbicide treatments. The two varieties respond similarly to the common citrus pests, except foot rot is a greater problem with Star Ruby than Ruby Red. Star Ruby fruit has less juice, but its juice has more acid and slightly more sugar than Ruby Red. Initial survey indicates that 2% of Star Ruby fruit may be seedy. A full assessment of Star Ruby's harvesting, packing, shipping, and marketing qualities must wait until a greater volume of fruit goes through these processes.

Star Ruby, a deep red, seedless grapefruit, was developed by inducing mutation through neutron irradiation of seed from the very seedy Hudson grapefruit. Amongst the resultant seedlings were some which had very red but seedless fruit. Budwood from one of these seedless selections, the Star Ruby, was released to Texas nurserymen in March, 1970. Based on tree movements from nurseries, an estimated 2,000 to 2,500 acres in the Lower Rio Grande Valley are now planted to Star Ruby (4). The first commercial harvest of this fruit in 1974 was primarily marketed as gift fruit or in special promotions. It is being tested in California and Arizona, under quarantine in Florida, and widely distributed in experimental plantings throughout the world (1). In view of the current interest in and production of this new grapefruit, this summarization of 5 years of data, observations, and reports on all aspects of the Star Ruby is presented.

### PROCEDURE

Most of the data came from 10 experimental plots of 5 to 10 acres, each in which Star Ruby and old-line Ruby Red trees were planted together for comparison. These plots, located from east of Brownsville to northwest of Mission, were roughly distributed in proportion to the Valley's citrus acreage (4). Tree growth and yield data were taken from a sample of 20 to 60 trees in each plot. Fruit quality and juice analyses were determined from samples of 12 to 24 fruit. For the seediness evaluation, four fruit, one from each compass quadrant, on 30 to 40 randomly selected trees in 12 orchards were examined. In addition to counting seeds, location and size of the fruiting branch and other pertinent notes regarding any seedy fruit were recorded. Where appropriate, analyses of variance, regression analyses, and Duncan's multiple range tests were used to statistically evaluate the data.

Though understandably subjective, the observations, opinions, and reports offered by growers, packinghouse managers, and orchard caretakers are an important and much appreciated part of this report. Although remarks on such qualities as market acceptance, taste, consumer appeal, and ease of culture or handling the fruit are still largely untested, they are included with appropriate qualifications.

## TREE GROWTH AND APPEARANCE

Star Ruby trees grew almost identically with Ruby reds of equal age in the same orchard (Table 1). Orchard site and management exerted the greatest influence on trunk growth (Fig. 1). Orchards 1, 2, and 3 were all planted within the same 4-month period. In orchard number 1, the trees received optimal care, and grew very rapidly until they started bearing at 3 years of age. In orchard number 2, about half the trees, planted in heavy, poorly drained soil, had poor, erratic growth which lowered the orchard's average. Competition from uncontrolled weeds reduced the initial growth of the trees in orchard number 3. Elimination of the weed problem in the third year markedly accelerated the trees' growth rate.

The typical Star Ruby canopy is denser and more compact than the Ruby Red (3). This gives the Star Ruby a more even, globe-shaped silhouette compared to the rather straggly appearance characteristic of Ruby Red trees (Fig. 2).

The overall color of Star Ruby trees tends to be slightly lighter green than Ruby Reds. The color difference is accentuated in wintertime when Star Rubies may take a yellow, even chlorotic appearance. From whatever cause, the Star Ruby is more prone to leaf yellowing and discoloration than

**Table 1.** Size of Star Ruby and Ruby Red grapefruit trees after four years growth.

| | Trunk diameter | Canopy volume |
|---|---|---|
| | Inches | $Ft^3$ |
| Star Ruby | 4.2 | 462 |
| Ruby Red | 4.3 | 459 |

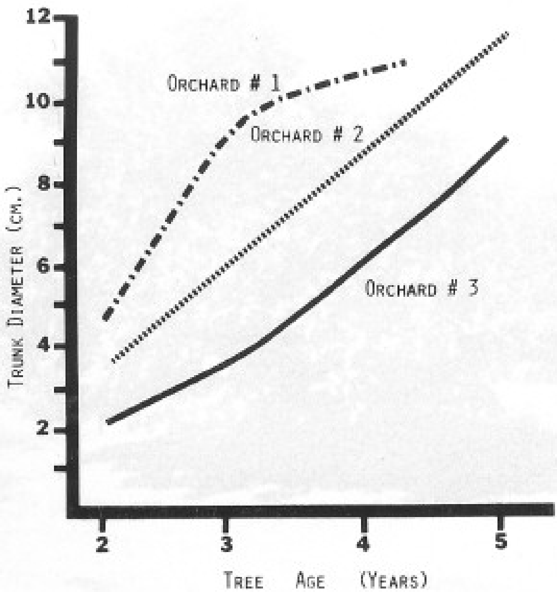


**Fig. 1.** A comparison of four years of trunk growth of Star Ruby trees in three different orchards.

**Table 2.** The average yields and yield variability of Star Ruby and Ruby Red grapefruit trees over four seasons.

| | | Tree age, years | | | |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6[1] |
| Star Ruby[2] | Yield (lb/tree) | 22 | 265 | 239 | 179 |
| | C.V.[3] | 121% | 43% | 59% | 75% |
| Ruby Red | Yield (lb/tree) | 60 | 130 | 294 | 94 |
| | C.V. | 63% | 50% | 28% | 106% |

[1]Year after the Dec. 1973 freeze.

[2]Average of four selections.

[3]C.V. = Coefficient of Variability = $\frac{\text{Standard Deviation}}{\text{Mean}} \times 100$

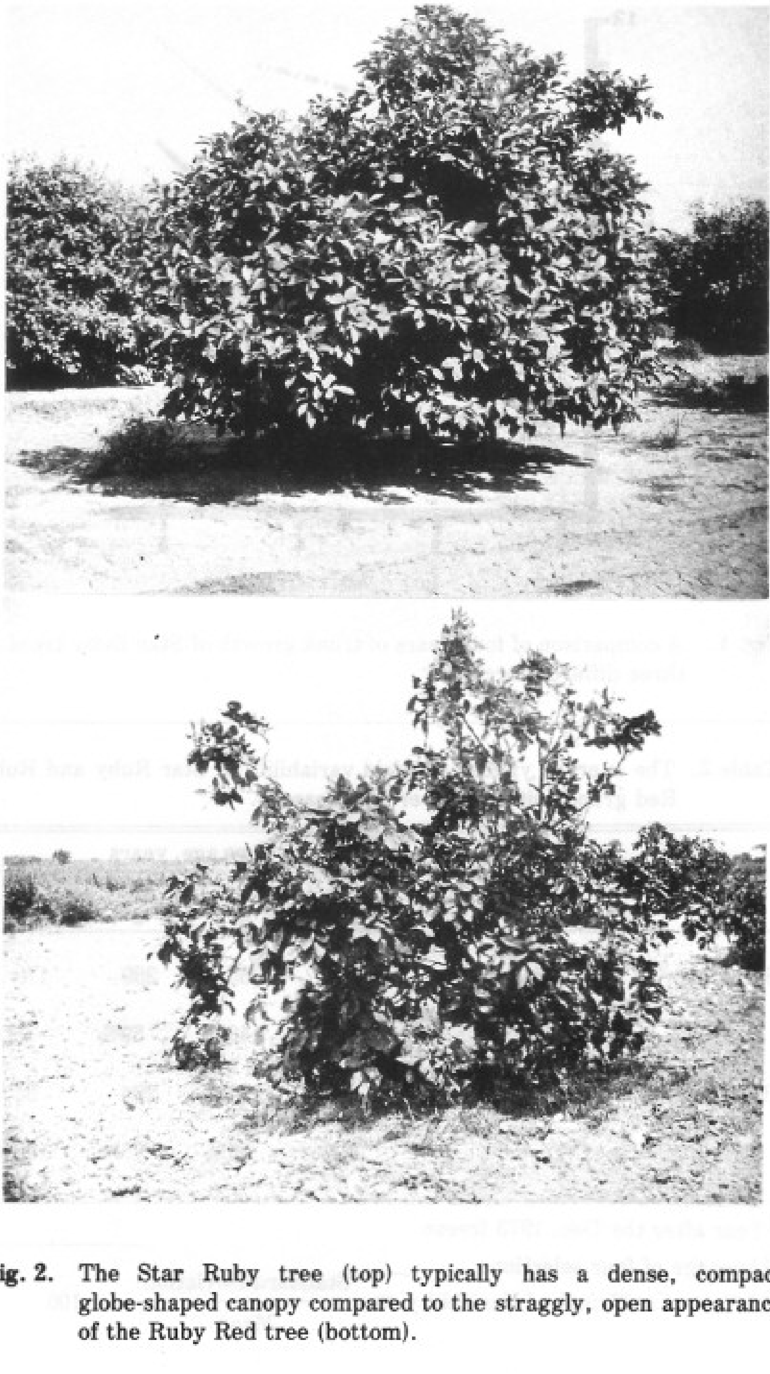

**Fig. 2.** The Star Ruby tree (top) typically has a dense, compact globe-shaped canopy compared to the straggly, open appearance of the Ruby Red tree (bottom).

the Ruby Red. Certain herbicides, for example, will cause considerable leaf yellowing and mottling in Star Ruby trees. Except in extreme cases, however, no reduction in tree growth or yields have resulted from the leaf yellowing and discoloration that characterizes the Star Ruby.

## CULTURAL AND CLIMATIC RESPONSES

*Water and Fertilizer Requirements*: In all valid comparisons with the Ruby Red, the Star Ruby has shown no differential water or fertilizer needs. The vigorous shoot and leaf growth observed in many plantings is probably due to the Star Ruby's nucellar origin rather than to more efficient use of nutrients or water. No successful attempts to overcome the above mentioned yellowing or chlorosis with extra fertilization have been reported.

*Herbicides*: The experiences of many growers have substantiated the Star Ruby's sensitivity to herbicides. Bromacil and simazine formulations have caused especially severe discoloring and are not recommended for use in young Star Ruby orchards. It is typical for Star Ruby trees to react to a herbicide applied at rates where Ruby Red trees remain a perfectly normal green (Fig. 3).

*Cold Hardiness*: Early reports that young Star Ruby trees were more easily injured by freezing temperatures have not been substantiated by observations made under controlled conditions. After the December 1973 freeze, a survey of two-year-old trees in a Star Ruby-Ruby Red test plot at the Citrus Center revealed no detectable differences in leaf loss or limb injury. Contrary to expectation, nearly all those wounds created by the frozen bark splitting were completely healed by June, 1974. The year after this freeze, Star Ruby yields in an orchard of older trees seemed less affected than the Ruby Reds (Table 2, see page 57).

Winter chlorosis which is accentuated in the Star Ruby, apparently results when either soil or air temperatures are too low. Since this response evidently involves chlorophyll synthesis or destruction which in turn is related to pigment metabolism in general, it is likely that in Star Ruby the whole complex process of color formation is quite different from the Ruby Red.

## PEST SUSCEPTIBILITY

No firm evidence has been offered that Star Ruby suffers either more or less from our major citrus insect pests.

Of our common diseases, only foot rot, *Phytophthora parasitica,* has proved a significant problem on Star Ruby trees. In the orchard, Star Ruby was more frequently infected and suffered more damage from foot rot than old-line Ruby Red (6). The greater damage in Star Ruby was apparently due to the very slow rate of healing of the foot rot wounds. Consequently,

**Fig. 3.** Leaves on tree in foreground show yellow, mottled, chlorotic pattern typical of Star Ruby discoloration. Ruby Red tree growing under same conditions and culture exhibits no injury symptoms.

all measures taken to prevent foot rot, e.g., high bud unions, avoiding poorly drained soils, and keeping tree crowns dry, are more important for Star Ruby trees. That these practices can reduce foot rot incidence has been well demonstrated. Star Rubies planted on a raised bed and drip irrigated had significantly fewer trees killed by foot rot than trees planted on level ground and flood irrigated (7).

## FRUIT SIZE, DISTRIBUTION, AND YIELDS

Observation and some limited data indicate the range in fruit sizes on Star Ruby trees compares to Ruby Red trees having similar fruit loads. When young, Star Ruby trees tend to bear more inside fruit than Ruby Reds. The uniform, compact canopy of the Star Ruby probably contributes to this tendency.

Four years of data from each of four Ruby selections planted in our oldest test plot showed per tree yields comparable to old-line Ruby Reds (Table 2). However, in characteristic nucellar fashion, the initial yields of the Star Rubies were lower and more variable than the Ruby Reds (Table 2).

## FRUIT APPEARANCE AND QUALITY

The early development and persistence of the red peel color on Star Ruby fruit has been described (3). In one season's test, a comparison of Star Ruby with Ruby Red fruit indicated no differences in average fruit size, percent number 1 grade, or type and number of peel blemishes. However, on a fresh weight basis, Star Ruby had 20% peel which was significantly less than the Ruby Red's 23%.

Concerning internal quality, Star Ruby fruit generally averages less juice and slightly more sugar than Ruby Red fruit. The Star Ruby's consistently higher acid content tends to give its juice a lower solids to acid ratio (Table 3). Variability between seasons, orchards, and even trees also contributes greatly to the quality differences between fruit varieties and even individual fruits.

## SEEDINESS

After several growers reported finding seedy fruit on their Star Ruby trees, an investigation was initiated to determine the extent and nature of seediness in fruit from our test plots and other bearing Star Ruby orchards. The results showed slightly less than 2% of the fruit were seedy (Table 4).

While this exceeds the occurrence of seediness in Ruby Red, it is low compared to the mutations and chimeras reported for some citrus species (2). Seedy fruit was typically found in clusters located on the larger, more mature branches near the trunk (Table 4). Because of its commercial importance, the phenomenon of seediness in Star Ruby fruit will continue to be studied in subsequent seasons.

## HARVESTING, PACKING, AND SHIPPING

Because of the excessive thorniness typical of nucellar trees, pickers have been reported to get a premium for harvesting Star Ruby orchards. Other than this, the quantity of Star Rubies picked to date has been too limited to uncover any general or consistent harvesting or packing problems. Several instances of excessive fruit softening in late spring have been cited and are being studied. Preliminary observations suggest it could be a season or an orchard related problem.

In our initial storability tests, Star Ruby fruit appeared more susceptible to such post-harvest diseases as blue mold, stem end rot, and brown rot (Table 5). The extreme variability between seasons and batches of fruit caused few of these differences to be statistically significant. Although packers have not reported any special spoilage problems in shipping Star Ruby, the subject will merit continued study as the volume of Star Ruby being marketed increases.

**Table 3.** The internal quality characteristics of Star Ruby and Ruby Red grapefruit on three harvest dates.

| Test date | | Acid in juice | Solids/acid ratio | Juice | Soluble solids in juice |
|---|---|---|---|---|---|
| | | % | | % | % |
| | Star Ruby | .93* | 8.8** | 55.9N.S. | 8.1** |
| Feb. 1972 | Ruby Red | .87 | 10.4 | 57.1 | 9.2 |
| Average: Nov., Feb., Apr. | Star Ruby | 1.15** | 8.0N.S. | 46.1** | 8.8** |
| 1973 to 1974 | Ruby Red | .99 | 7.8 | 52.1 | 7.7 |
| Dec. 1975 | Star Ruby | 1.05** | 8.2** | 53.7* | 8.6** |
| | Ruby Red | .97 | 8.5 | 55.4 | 8.2 |

*, **, N.S. = statistically significant differences at 5%, 1%, or not significant, respectively.

## PROCESSING AND MARKETING

The USDA's Food Crops Utilization Laboratory in Weslaco has been testing various blends of Star Ruby and Ruby Red grapefruit juice. Preliminary results indicate 20 to 30% Star Ruby juice combined with Ruby Red gives a product of excellent flavor and color (personal communication with Mr. Robert Cruse, Research Chemist, USDA Food Crops Utilization Laboratory).

The similarity in texture and quality between fruit sections of the Duncan and Star Ruby grapefruits suggests Star Ruby would yield an excellent sectioned product, but this possibility has not yet been explored.

To date, most of the Star Rubies have been marketed as gift fruit or in special promotions. Scattered reports from both shippers and retailers have indicated the fruit was well received by their customers. A more definitive consumer assessment must wait until a larger volume of Star Ruby fruit can be marketed.

**Table 4.** The occurrence and characteristics of seediness in Star Ruby grapefruit.

| Class | Number of seeds/fruit | Percent of fruit in class | Diameter of Branch bearing fruit | Number of fruit per branch |
|---|---|---|---|---|
| | | % | inches | |
| Seedless | 0 to 12 | 98.1 | .21 | 1.6 |
| Seedy | over 12 | 1.9 | .38 | 4.2 |

**Table 5.** Postharvest decay losses in Star Ruby and Ruby Red grapefruit for four seasons.

| | Percent total decay in: | | | |
|---|---|---|---|---|
| | 1971 to 1972 | 1972 to 1973 | 1973 to 1974 | 1974 to 1975 |
| Star Ruby | 23.7 | 1.0 | 7.5 | 8.7 |
| Ruby Red | 6.8 | 1.0 | 5.8 | 1.7 |

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# Influence of Nitrogen, Phosphorus, and Potassium on Red Grapefruit

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## ABSTRACT

Studies were conducted to determine the influence of N, P, and K fertilizers on fruit yield and quality and nutrient concentration in leaves of red grapefruit (*Citrus paradisi* Macf.). Nitrogen application increased yields during the second, fourth and fifth years of the study and increased N concentration in leaves after the third year of application. Phosphorus or K did not influence yield, fruit quality, or nutrient concentration in leaves.

Production of citrus is a major horticultural enterprise in South Texas. Most of the citrus industry is located on well-drained sandy loam soils, but fertilizer use varies from grove to grove. The most consistent yield response has been from application of fertilizers containing N. Potassium content of Rio Grande Valley soils is quite high because of the nature of the soil clays present (3). Phosphorus content of soils of the area is generally medium to very high, but there have been undocumented reports of response to P by citrus. Several factors influence the magnitude of response to fertilizer, particularly N. Maxwell and Dacus (8) obtained a response to N with trees under sod culture, but when the sod culture was removed no response was obtained (7). No response to P or K was obtained with or without sod (7,8). In a two year study, Leyden (4) found that one pound of N per tree was adequate under conditions of the study and that split application of N did not increase yields over single application. In another study (5), P application increased extractable soild P but did not influence concentration of P in leaves of grapefruit. In the same studies, application of N reduced leaf concentration of P and K. Madden (6) concluded that leaf N concentrations in Rio Grande Valley citrus were extremely variable. Dacus and Shull (2) found no response to N by grapefruit during the first two years of a study on Willacy fine sandy loam, but a significant N response was obtained the second two years of the study. Grapefruit did not respond to application of P or K during the study.

To gain additional information concerning fertilizer requirements of grapefruit, a study was conducted in cooperation with Rio Farms, Inc., Monte Alto, Texas.

## MATERIALS AND METHODS

Research was conducted on red grapefruit to determine the influence of annual applications of N, P, and K fertilizers on fruit yield and quality and nutrient concentration in leaves. Treatments were initiated in March 1968. The trees were planted in February 1965 (180 trees/acre), and the first fruit was harvested in December 1968.

Treatments (Table 1) were broadcast over the plot area and incorporated into the soil by disking or rotovating. The design was a 4 x 4 Latin square with 4 trees per plot with each plot separated by a row of trees. Irrigation and other cultural practices common to the area were used except for fertilizer application. Fruit was harvested each year by sizing [less than (<) 96 and greater than (>) 96] and weighing fruit from each tree. Samples consisting of eight fruit per tree were taken for juice quality analyses at each harvest. Leaf samples were taken in July of each year by removing 24 leaves per treatment from the spring flush of non-fruiting terminals. Leaves were washed and rinsed in distilled water then dried at 70°C. Leaves were ground then dry ashed (1) and analyzed for zinc (Zn), iron (Fe), manganese (Mn), magnesium (Mg), calcium (Ca), and potassium (K) by atomic absorption, total N by Coleman nitrogen analyzer and P colorimetrically by the molybdenum blue method. Soil samples (0 to 6-inch depth) were taken each year prior to spring treatment application. Soil at the experimental site was well-drained sandy loam (described in Table 2).

**Table 1.** Description of treatments applied during the study.

| Treatment | |
|---|---|
| 1 | Check—no fertilizer |
| 2 | 66 lbs N/acre 1968 to 1971, 132 lbs N/acre 1972 to 1974 |
| 3 | 66 lbs N/acre 1968 to 1971, 132 lbs N/acre 1972 to 1974<br>132 lbs $P_2O_5$/acre each year 1968 to 1974 |
| 4 | 66 lbs N/acre 1968 to 1971, 132 lbs N/acre 1972 to 1974<br>132 lbs $P_2O_5$/acre each year 1968 to 1974<br>33 lbs $K_2O$/acre each year 1968 to 1974 |

**Table 2.** Analysis of soil at the experimental site.

| | meq[1]/100 g | | | ppm[2] |
|---|---|---|---|---|
| | PH | K | Mg | P |
| Willacy fsl | 7.2 | 0.9 | 1.3 | 8.1 |

1 extracted with ammonium acetate
2 Extracted with $NaHCO_3$ at pH 8.5

## RESULTS AND DISCUSSION

Total fruit yield or size of fruit was not influenced by fertilizer treatment during 1968 to 1969 (Table 3). This was the first year that fruit was produced by the trees. Nitrogen increased the production of >96 size and total fruit in the second year of the study (1969 to 1970), but size <96 fruit was not influenced by treatment. Treatment did not affect fruit yield or size during the 1970 to 1971 season. Nitrogen increased the yields of >96 and total yields of fruit in 1971 to 1972 and 1972 to 1973. A freeze occurred in 1973 that severely reduced fruit yields of the 1973 to 1974 crop. Nitrogen appeared to increase yields but variations were so great between plots that there was no difference in treatment means. Phosphorus or K did not influence yield during the period of study.

Nitrogen application increased the concentration of N in leaves after the third year of application (Table 4). Nitrogen concentration in leaves decreased each year in trees receiving no N. Concentration of P in leaves decreased with N application during 1972 and 1973 (Table 4), and severe N deficiency appeared to result in abnormally high P concentrations in leaves. These results are consistent with findings of Leyden (5). Phosphorus application did not influence P concentrations in the leaves in any of the years of the study. Phosphorus concentrations of about 0.10% P appeared to be consistent with maximum yield produced during the study. Potassium concentrations in leaves were generally reduced with N application (Table 4), but they were not influenced by K application to the soil. Maximum yields were obtained in this study with leaf K concentrations of 0.5 to 0.7%. Calcium concentrations in the leaves were increased with the application of N during 1972 and 1973 (Table 4), but they were not influenced by P or K application at any time during the study. Application of N, P, or K did not influence Fe, Mg, or Mn concentrations in the leaves during the experimental period (Table 5). Zinc concentrations were reduced by application of N during 1973 (Table 5), but they were not affected the remainder of the years.

**Table 3.** Influence of N, P, and K on size distribution and yield of grapefruit.

| | Year | | | | | |
|---|---|---|---|---|---|---|
| Treatment[1] | 1968 to 1969 | 1969 to 1970 | 1970 to 1971 | 1971 to 1972 | 1972 to 1973 | 1973 to 1974 |
| | | | Tons/acre < 96 | | | |
| 1 | 0.43 | 0.61 | 2.10 | 3.26a[2] | 1.44 | 3.70 |
| 2 | 0.54 | 0.68 | 3.78 | 5.36b | 6.45 | 8.46 |
| 3 | 1.86 | 0.80 | 2.86 | 7.00b | 4.50 | 9.96 |
| 4 | 0.50 | 0.82 | 3.55 | 6.48b | 9.13 | 4.47 |
| | | | Tons/acre > 96 | | | |
| 1 | 0.46 | 1.86a[2] | 1.61 | 6.68a | 5.29a | 2.25 |
| 2 | 0.58 | 2.92b | 2.61 | 12.74b | 15.58b | 2.66 |
| 3 | 0.94 | 2.50b | 2.27 | 11.87b | 13.03b | 2.59 |
| 4 | 0.34 | 2.75b | 2.93 | 11.22b | 11.99b | 3.09 |
| | | | Tons/acre Total | | | |
| 1 | 0.89 | 2.47a[2] | 3.71 | 9.94a | 6.73a | 5.95 |
| 2 | 1.12 | 3.60b | 6.39 | 18.18b | 22.03b | 11.12 |
| 3 | 2.80 | 3.30b | 5.13 | 18.87b | 17.53b | 12.55 |
| 4 | 0.84 | 3.57b | 6.48 | 17.70b | 21.12b | 7.56 |

[1]Description of treatments given in Table 1.

[2]Means in a column not having the same letter beside them differ at the 0.05 level of significance. Columns without letters indicate no differences.

Fertilizer application did not influence brix-acid ratio, ml of juice/gm of fruit, or brix of grapefruit juice during this study (Table 6). Nitrogen application increased juice acidity in 1973 to 1974 (Table 6), but it did not influence acidity during the other years of the study. Rind thickness of fruit was measured on <96 and >96 size fruit the last 3 years of the study. Nitrogen application generally resulted in thicker rinds (Table 7), but the trend was only significant during 1973 to 1974 on >96 size fruit.

Visual comparisons were made of fruit samples from each treatment each year during the study but no influence of treatment on shape or color of fruit was visible.

**Table 4.** Influence of N, P, and K fertilizer on nutrient concentration in grapefruit leaves.

| Treatment[1] | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| | | | | % N | | |
| 1 | - | 2.23 | 2.16 | 2.11a[2] | 1.64a | 1.50a |
| 2 | - | 1.98 | 2.28 | 3.01b | 1.96ab | 2.15b |
| 3 | - | 2.26 | 2.22 | 2.75b | 2.12b | 2.00b |
| 4 | - | 2.32 | 2.18 | 2.48b | 1.91ab | 2.01b |
| | | | | % P | | |
| 1 | 0.12 | 0.10 | 0.14 | 0.13 | 0.24a[2] | 0.26a |
| 2 | 0.11 | 0.09 | 0.09 | 0.10 | 0.10b | 0.11b |
| 3 | 0.10 | 0.09 | 0.10 | 0.11 | 0.10b | 0.11b |
| 4 | 0.10 | 0.08 | 0.10 | 0.10 | 0.10b | 0.11b |
| | | | | % K | | |
| 1 | 1.18 | 0.98 | 1.56 | 1.34a[2] | 1.47a | 1.72a |
| 2 | 1.05 | 0.80 | 1.23 | 0.72b | 0.57b | 0.80b |
| 3 | 0.94 | 0.79 | 1.00 | 0.73b | 0.64b | 0.75b |
| 4 | 0.95 | 0.72 | 1.16 | 0.69b | 0.49b | 0.82b |
| | | | | % Ca | | |
| 1 | 5.3 | 5.7 | 5.4 | 5.1 | 4.9a[2] | 4.3a |
| 2 | 5.6 | 5.7 | 5.2 | 5.6 | 5.7b | 5.4b |
| 3 | 5.4 | 5.3 | 5.8 | 5.6 | 5.7b | 5.4b |
| 4 | 5.5 | 5.7 | 5.4 | 5.7 | 6.1b | 5.6b |

[1] Description of treatments given in Table 1.

[2] Means in a column not having the same letter beside them differ at the 0.05 level of significance. Columns without letters indicate no differences.

**Table 5.** Influence of N, P, and K fertilizer on nutrient concentration in grapefruit leaves.

| Treatment | Year 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| | | | | ppm Fe | | |
| 1 | 83[2] | 102 | 69 | 112 | 95 | 130 |
| 2 | 93 | 104 | 71 | 95 | 90 | 137 |
| 3 | 85 | 101 | 61 | 89 | 88 | 132 |
| 4 | 82 | 98 | 66 | 88 | 94 | 132 |
| | | | | % Mg | | |
| 1 | 0.34[2] | 0.38 | 0.28 | 0.28 | 0.24 | 0.23 |
| 2 | 0.36 | 0.38 | 0.28 | 0.33 | 0.25 | 0.28 |
| 3 | 0.33 | 0.36 | 0.29 | 0.34 | 0.26 | 0.28 |
| 4 | 0.35 | 0.39 | 0.29 | 0.32 | 0.26 | 0.28 |
| | | | | ppm Mn | | |
| 1 | 40[2] | 38 | 21 | 22 | 20 | 28 |
| 2 | 46 | 38 | 29 | 27 | 24 | 34 |
| 3 | 41 | 37 | 29 | 27 | 26 | 37 |
| 4 | 42 | 42 | 21 | 27 | 27 | 37 |
| | | | | ppm Zn | | |
| 1 | 28 | 19 | - | - | 57 | 45a[2] |
| 2 | 24 | 16 | - | - | 52 | 31b |
| 3 | 24 | 15 | - | - | 50 | 28b |
| 4 | 26 | 16 | - | - | 55 | 29b |

1 Description of treatments given in Table 1.

2 Means in a column not having the same letter beside them differ at the 0.05 level of significance. Columns without letters indicate no differences.

**Table 6.** Influence of N, P, and K fertilizer on grapefruit juice.

| Treatment[1] | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1968 to 1969[2] | 1969 to 1970 | 1970 to 1971 | 1971 to 1972 | | 1972 to 1973 | | 1973 to 1974 | |
| | | | | < 96 | > 96 | < 96 | > 96 | < 96 | > 96 |
| | brix/acid ratio | | | | | | | | |
| 1 | 7.1[3] | 10.2 | 8.6 | 9.0 | 8.4 | 10.1 | 10.3 | 9.2 | 8.9 |
| 2 | 7.6 | 9.9 | 8.9 | 9.0 | 8.8 | 9.7 | 10.5 | 8.1 | 8.1 |
| 3 | 7.6 | 10.2 | 8.7 | 9.3 | 9.2 | 9.9 | 10.1 | 9.0 | 8.5 |
| 4 | 7.5 | 10.1 | 9.2 | 9.0 | 8.8 | 10.1 | 10.5 | 8.4 | 7.7 |
| | ml juice /gm of fruit | | | | | | | | |
| 1 | 0.45 | 0.41 | 0.50 | 0.52 | 0.52 | 0.51 | 0.51 | 0.44 | 0.46 |
| 2 | 0.49 | 0.55 | 0.52 | 0.49 | 0.56 | 0.52 | 0.50 | 0.48 | 0.47 |
| 3 | 0.48 | 0.56 | 0.50 | 0.55 | 0.53 | 0.53 | 0.51 | 0.50 | 0.50 |
| 4 | 0.47 | 0.53 | 0.51 | 0.53 | 0.58 | 0.52 | 0.51 | 0.47 | 0.49 |
| | brix | | | | | | | | |
| 1 | 9.1[3] | 9.6 | 9.0 | 9.1 | 8.6 | 9.4 | 9.3 | 9.6 | 9.6 |
| 2 | 8.9 | 9.3 | 8.9 | 9.3 | 8.9 | 9.4 | 9.3 | 10.5 | 10.5 |
| 3 | 9.1 | 9.5 | 9.1 | 9.3 | 8.9 | 9.3 | 9.0 | 10.6 | 10.3 |
| 4 | 9.1 | 9.4 | 9.2 | 9.3 | 8.3 | 9.7 | 9.6 | 10.8 | 10.7 |
| | % acid | | | | | | | | |
| 1 | 1.28 | 0.94 | 1.04 | 1.01 | 1.03 | 0.93 | 0.91 | 1.05a[3] | 1.08a |
| 2 | 1.17 | 0.94 | 1.00 | 1.04 | 1.01 | 0.97 | 0.89 | 1.30b | 1.32b |
| 3 | 1.20 | 0.93 | 1.04 | 1.00 | 0.97 | 0.95 | 0.89 | 1.18b | 1.22b |
| 4 | 1.21 | 0.93 | 1.01 | 1.04 | 0.94 | 0.96 | 0.92 | 1.29b | 1.39b |

1 Description of treatments given in Table 1.
2 Samples for 1968 to 1971 juice analysis consisted of an equal number of < 96 and > 96 size fruit.
3 Means in a column not having the same letter beside them differ at the 0.05 level of significance. Columns without letters indicate no differences.

**Table 7.** Influence of N, P, and K fertilizer on average rind thickness (mm) of grapefruit.

| Treatment[1] | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1971 to 1972 | | 1972 to 1973 | | 1973 to 1974 | |
| | < 96 | > 96 | < 96 | > 96 | < 96 | > 96 |
| 1 | 5.0 | 6.2 | 5.0 | 6.3 | 5.5 | 5.8a[2] |
| 2 | 5.3 | 6.7 | 5.5 | 7.4 | 5.3 | 7.2b |
| 3 | 4.8 | 5.9 | 5.4 | 7.5 | 5.1 | 6.5b |
| 4 | 5.0 | 6.2 | 5.6 | 7.3 | 5.3 | 6.4b |

1 Description of treatments given in Table 1.
2 Means in a column not having the same letter beside them differ at the 0.05 level of significance. Columns without letters indicate no differences.

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## Earnings Valuation: One Technique For Appraising Citrus

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### ABSTRACT

The valuation of a citrus orchard can be made through an earnings analysis. Tree and land values are estimated separately. The net income to the trees is capitalized at a rate of return that includes charges for interest on the tree investment, depreciation, and freeze risk. The tree value is then added to the value of the land plus improvements to obtain the orchard's complete value.

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Citrus orchards in the Lower Rio Grande Valley are typically sold on an acre basis without separating the value of the land from that of the trees. Consequently, a prospective buyer must attempt to isolate and estimate two values: land and trees. Complicating this problem is the fact that these values do not necessarily respond equally to changes in the economy.

While there are economic pressures that affect land and tree values, the land's value depends more upon changes in inflation rates, urban pressures, and speculation. The tree value is influenced by crop prices, yields, availability and profitability of alternative investments, attitudes toward risk, and the esthetics of owning an orchard.

The prospective orchard buyer must estimate the impact of these factors to effectively appraise the current value of an orchard. This paper offers a simplified approach that allows the buyer to value citrus trees and land separately.

### METHODOLOGY

*Estimating the value of the land.* Land value estimates are best determined by comparative sales data on land similar to that on which the orchard is situated. Several factors should be considered in making this analysis:

1. Consider time. The land market today—3 to 5-year-old land sales data may not adequately reflect current economic influences.

2. Consider size. Generally small land tracts sell for higher prices than larger tracts.

3. Consider location. The land's proximity to town, markets, residential subdivisions, paved roads, etc., influences its value.

4. Consider improvements. Irrigation system, drainage tile, and leveling improves the land's productivity and consequently its value.

5. Consider special factors such as zoning, irrigation district, etc.

*Estimating the value of trees.* One method utilized by appraisers, an earnings valuation approach, theorizes that value can be estimated from the present worth of average annual net income produced during the productive life of the asset. For a citrus orchard, the net annual income is the return to trees after deducting the expenses required to grow the crop. The formula is:

$$\text{Value of trees} = \frac{\text{Annual net income to trees}}{\text{A rate of return}}$$

The technique takes expected annual net income of the trees and capitalizes it (divides it) by a personally justifiable rate of return on the investment. The raw land is valued at its current market value plus improvements.

## DETERMINING A RATE OF RETURN FOR CITRUS TREES

Three components should go into the development of a rate of return for citrus trees: interest on the tree investment, depreciation on trees, and freeze risk.

*Interest on tree investment.* If the orchard is financed, the rate of interest charged by the lender can be used; if purchased with private funds, an "opportunity cost" must be charged. An opportunity cost is a charge for the income lost from other investments because the investor has his money in citrus can not take advantage of other investment opportunities.

The determination of the interest charge on privately invested funds is highly subjective. A prospective buyer may accept a low interest rate of return on his investment today because he anticipates that land value will increase. In another instance, a buyer may be willing to accept a low rate of interest return on his orchard because he lives on his land and enjoys the non-monetary reward of living in an uncrowded, pleasant environment.

An orchard that generates a $300 net income per acre per year would be valued at $10,000 per acre if capitalized at an interest charge of 3%. The same orchard is valued at $3,750 if capitalized at 8%. The difference in these interest charges, given the same net income from the orchard, indicates what would happen to tree value due to the non-economic, often capricious factors cited above. For the interest rate on tree investment, the rate charged on long-term loans, presently about 9%, may be used. An alternative rate is the yield on good grade, long-term bonds or a price-earnings ratio on stocks, about 8.4 and 7.7%, respectively, over the last 5 years (1).

*Depreciation.* Through depreciation an attempt is made to recapture the declining value of the trees during their productive life. Charging a rate of return to the orchard for depreciation reflects the annual loss in the orchard's total productivity as trees grow older. For example, a 5-year-old orchard has an expected remaining life of 20 yars. The trees at first increase in productivity, then their production will decline and finally the trees will be removed. With a 20-years' life, 5% of the tree life is expended each year (100% + 20 = 5%) for a depreciation rate of 5%.

*Freeze risk.* Protecting an orchard investment from a freeze with a protection system can cost as much as $1,588 an acre (2). This investment must also receive a rate of return. The grower who does not have a freeze protection system is in effect saying that the orchard's rate of return is not sufficient in relation to the risk of a freeze. However, if a freeze occurs, he must pay for replanting or repairing the orchard, which is again an investment that must have a profitable rate of return. In establishing a charge for the risk of a severe freeze, the prospective buyer can use the cost of funds required to purchase a freeze protection system or to pay for tree replacement or repair. This is an opportunity rate of interest like that developed for the interest charge on the tree investment.

## ESTIMATION OF THE ORCHARD'S NET INCOME

*Gross income estimation.* The buyer should consider past yields of the orchard with those from neighboring orchards, Valley averages, or those reported in research publications. He should consider tree age and at least 3 to 5 years' past yield records when making these comparisons. To estimate citrus prices, again 3 to 5 years' past prices are the best available guide to future prices.

*Expense estimation.* Expenses should be estimated by including every *typical* expense in growing an orchard. Guides to expected production costs are available at the Texas A&I Citrus Center and The Texas A&M Extension Center. Typical expenses included in citrus production are:

| *Annual operating expenditures* | *Capital expenditures* |
|---|---|
| 1. Fertilization | 1. Depreciation on trees, irrigation system, other property assets |
| 2. Insect and disease control | 2. Interest on investment (land, trees, irrigation system, other property assets) |
| 3. Weed control | |
| 4. Irrigation (water and labor) | |
| 5. Taxes (school, state and county, water district) | |
| 6. Interest on operating money | |
| 7. Management fees | |
| 8. Insurance | |

## THE ESTIMATING PROCEDURE

Assume an orchard is 5-years old with a remaining 20-year life and an average expected production of 16 tons per acre. The anticipated future price is $50 per ton based on an average of 1970 to 1975 prices. The gross income expected is $800 per acre (Table 1). The annual operating expense is estimated at $200 per acre. Taxes are $15 per acre per year. The grove operator has charged a $139 management fee. Finally, there is a $35 a year charge for interest on the money used to produce the crop. This gives a total annual operating expenditure of $389 per acre, which subtracted from gross income nets $411 per acre to the trees, land, and improvements.

The next step is to separate from net income of the trees any costs associated with land and allied assets such as an irrigation system. The annual cost of the irrigation system can be determined by depreciating the $250 per acre system over a 25-year life. The annual charge on the irrigation system is $10 per acre ($250 ÷ 25 years = $10) which leave a net income to trees and land of $401.

The annual charge to the land is based on the rate of interest required to service the land debt or 8% per year. This is $72 per acre, leaving a net income to the trees of $329. This $329 net income to the trees is the estimate of the orchard's profitability and is the figure used as net income in the value formula.

The overall rate of return segment of the formula is determined by summing its three components: interest on tree investment at 8%, depreciation at 5%, and freeze risk at 8%, for an overall return rate of 21%.

**Table 1.** A per acre orchard valuation statement based on the earnings method of appraisal.

| | | | |
|---|---|---|---|
| Gross income ($50/ton x 16 tons/acre) | | | $800 |
| Annual care expenses | $200 | | |
| Taxes | 15 | | |
| Management fee | 139 | | |
| Interest on annual expenses | 35 | | |
| Expenditures | | | -$389 |
| Net income to trees, land, and improvements | | | |
| Less depreciation on irrigation system ($250 ÷ 25 years) | | | 10 |
| Net income to trees and land | | | $401 |
| Less interest on land ($900 at 8%) | | | 72 |
| Net income to trees | | | $329 |
| Rate of return on tree investment | | 8% | |
| Depreciation of trees (20-year life) | | 5% | |
| Rate of return on freeze risk | | 8% | |
| Overall rate of return | | 21% | |
| Indicated value of trees[1] ($329 ÷ .21) | | | $1,567 |
| Add value of land with irrigation system | | | $1,100 |
| Value of trees and land | | | $2,667 |

[1]Tree value is calculated with the formula on page 2.

Finally, a value for the trees is obtained by dividing the net income to the trees, $329, by the required 21% overall return rate. This capitalization of net income provides a value for the trees of $1,567. The addition of the raw land value, $900, and the remaining value of the irrigation system, $200, provides a total orchard value of $2,667 per acre.

If the orchard is sold with the current crop, the value of the crop can be estimated by the amount of expenditures that have gone into production of the crop this year. The expected sales price of the current crop should not be used. Sales price presumes an ability to market the fruit, a potentially false profit margin, and freedom from weather problems which might negate all crop profits.

## DISCUSSION

Before an appraisal by the buyer is attempted, he should critically consider the physical points that affect citrus productivity. Weather conditions, markets, diseases, soil problems, etc., must be evaluated and considered prior to any consideration of an orchard venture. Only after the prospective buyer has considered these factors should he look for a specific orchard to buy.

The procedure presented is an attempt to aid prospective citrus buyers in the decision making process. There are several techniques utilized by rural appraisers to value citrus orchards. The earnings approach is just one, but it does emphasize the important factors to consider and analyze BEFORE buying an orchard.

It is also suggested that buyers utilize this process on several orchards and check their value estimates against sale prices for these orchards. This provides a unique insight into the non-income factors present in the orchard market.

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## Cost Comparison of Drip and Flood Irrigations Systems

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### ABSTRACT

Drip irrigation and conventional surface flood irrigation for citrus orchards are compared with respect to installation and operating costs. Circumstances which might favor one system over the other are considered.

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Research since 1970 indicates that newly-planted citrus trees under drip irrigation used 2-acre inches of water in the first year as compared to 15-acre inches under strip irrigation. In the second year, drip used 2.2 and strip 9.6-acre inches (1). The difference in the required amount of water under the two systems lessens as the trees grow. In a year of normal rainfall, a drip irrigation system used 20% less water than a surface flood system in a mature orchard without affecting yield (2).

The Soil Conservation Service estimates that in the Lower Rio Grande Valley, about 2% of the citrus (1,550 acres) were under drip irrigation in June 1975 (4). The purpose of this study is to compare drip irrigation and conventional surface flood irrigation with respect to installation and operating costs and to consider the circumstances which might favor one system over the other.

### IRRIGATION SYSTEMS COMPARED

Most drip irrigation systems consist of three parts:

1. A pump station including an electric motor, pump, filter, water meter, a pole, meter and power panel for electric service, and a time clock.

2. A distribution system consisting of rigid polyvinyl chloride (PVC) underground pipe conducting water to the orchard and then flexible polyethylene lines along each tree row with one to four emitters at each tree.

3. A fertilizer system consisting of a tank and a metering pump for injecting liquid fertilizer into the drip system.

The rate of water application through the drip system is based on open pan evaporation and consideration of tree canopy size. A monthly guide to drip irrigation requirements for trees of various ages is given in Table 1. A typical flood irrigation is considered to be 6 acre-inches. At the Citrus Center in the past 20 years, we have averaged five flood irrigations annually for a total of 30 acre-inches of water a year. This is 10% more than that for mature trees under drip irrigation (Table 1).

**Table 1.** Drip irrigation requirements for trees of various ages.[1]

| | Acre inches per acre[2] | | |
|---|---|---|---|
| Month/year | 1st | 3rd | 6(+)[3] |
| Jan. | .09 | .33 | .72 |
| Feb. | .09 | .40 | .85 |
| Mar. | .13 | .59 | 1.26 |
| Apr. | .16 | .80 | 1.69 |
| May | .27 | 1.35 | 2.87 |
| June | .30 | 1.50 | 3.20 |
| July | .45 | 2.24 | 4.79 |
| Aug. | .36 | 1.82 | 3.88 |
| Sept. | .32 | 1.60 | 3.42 |
| Oct. | .28 | 1.41 | 3.01 |
| Nov. | .10 | .49 | 1.04 |
| Dec. | .06 | .30 | .63 |
| Total | 2.61 | 12.83 | 27.36 |

1 Assumes an average annual rainfall of 23 inches.

2 Based on 116 trees per acre or an emitter every 5 ft along each row.

3 Fifteen ft canopy diameter.

For comparison we have assumed a 20-acre tract of unleveled land, 1,320 x 660 ft, on which we intend to plant a citrus orchard with 116 trees per acre. For flood irrigation the land would be leveled, while for drip irrigation leveling would be omitted. A reservoir providing a 6-day water supply at time of peak demand is included with the drip system. The irrigation system layout under either flood or drip is illustrated (Fig. 1).

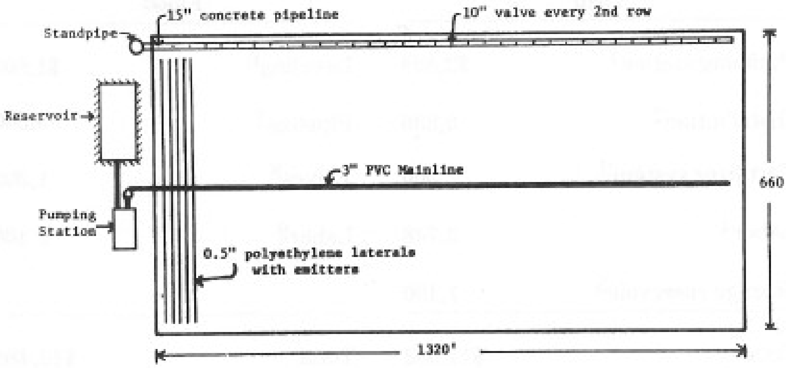


**Fig. 1.** Irrigation layout for flood and drip irrigation systems.

The pump station for the drip installation is located at one end of the orchard near the reservoir. A 3-inch PVC pipe runs 1,300 ft through the center of the orchard. From this header line, 0.5-inch flexible polyethylene tubing runs 300 ft north and south with emitters appropriately spaced. For flood irrigation, a 15-inch concrete pipeline with rubber-gasketed joints runs 1,300 ft east and west along one side of the orchard. A 10-inch valve is installed at every second tree row. There is no reservoir with the flood system.

## COST COMPARISON OF THE TWO SYSTEMS

Cost comparisons in analyzing irrigation systems must include installation costs and annual operating costs. The installation cost estimates, based on 1975 prices, for 20-acre drip and flood irrigation systems are presented (Table 2). For the systems developed, the cost of the drip installation exceeds that of the flood system by about $30 per acre. Several modifications of the drip system could alter the cost situation. In the example, a reservoir, a sand filter, and a screen filter have been included. At some Valley locations, one or more of these might not be needed. If both the reservoir and the sand filter were omitted, the cost of the drip system would be reduced by $2,300 for the 20-acre installation or $115 an acre. The drip system would then cost $439 per acre compared with $524 per acre for the flood system.

**Table 2.** Installation cost estimates of drip and flood irrigation systems for twenty acres.

| Irrigation System | | | |
|---|---|---|---|
| Drip | | Flood | |
| Pumping station[1] | $2,898 | Leveling[6] | $1,800 |
| Distribution[2] | 3,836 | Pipeline[7] | 5,280 |
| Fertilizer system[3] | 500 | Valves[8] | 1,300 |
| Labor[4] | 2,748 | Labor[9] | 2,100 |
| Storage reservoir[5] | 1,100 | | |
| Total | $11,082 | Total | $10,480 |
| Per acre | $554.10 | Per acre | $524.00 |

[1]Includes an electric 3-hp centrifugal pump, concrete slab, electrical panel, water meter, sand filter, and screen filter.

[2]Includes PVC pipe, polyethylene laterals, and microtubing emitters.

[3]Includes a 250 gallon fertilizer tank and metering pump.

[4]Estimated at 38% of complete material cost.

[5]A 0.25-acre reservoir 8-ft deep with lining.

[6]Assumes 300 cubic yards of soil moved per acre at $.30 per cubic yard.

[7]Concrete pipe at $4.00 per ft for 1,300 ft.

[8]Assumes a valve every two rows at $50 per valve.

[9]Assumes labor at $1.50 per ft of pipe plus valves.

A modification which would increase the cost of the drip system is the use of prefabricated drippers instead of microtubing. The example assumes two microtube emitters per tree at a cost of $.0083 per ft of emitter. With 116 trees per acre, this amounts to $7.70. The cost of prefabricated emitters ranges from about $.25 to $.50 or more per emitter. The cost per acre would be $58 for two emitters per tree utilizing the $.25 prefabricated emitter. The microtubing emitter decreases the total 20-acre installation cost by $1,006 or $50.30 per acre.

The annual operating costs for drip and flood irrigation systems are shown in Table 3. With newly planted trees, the operating cost in the first year is $22 an acre higher for drip than for flood irrigation. This difference becomes greater with time. For trees of bearing age, the cost of operating the drip system is $45 an acre higher than for flood irrigation.

Considering only out-of-pocket expenses, drip irrigation is $10 per acre less for newly-planted trees. This is due to lower water requirements per acre. However, as trees reach bearing age, water requirements increase and, consequently, electrical power usage increases. Thus, the out-of-pocket expenses with mature trees are $13 an acre more for drip than for flood irrigation.

Drip irrigation substitutes one type of manual labor for another. The drip system requires periodic emitter checks, filter cleaning, and blowing out of lines. In California, studies show that as much as $36 an acre per year were allocated to labor on drip systems (3). Some Valley growers have indicated operating labor costs as high as $32 an acre a year for their drip system. The $16 figure used in Table 3 is a modest estimate that assumes effective filtration with no major plugging of emitters. The labor charge also assumes that the drip system is completely operational and that all initial problems are worked out.

The cost of electricity is an important consideration in drip irrigation. The average monthly expenditure quoted by several Valley growers indicates that this charge varies from $30 to $80 per month on a 20-acre system. Assuming that the declining charge per kilowatt hour (kwh) is uniform throughout the Valley, this range is explained by differences in horsepower and hours of operation. We have seen many systems that are overpowered. In talking to growers, we find that most of them operate on a time schedule that supplies a great deal more water than indicated in Table 1. The annual operating cost for most existing drip systems probably exceeds that given in Table 3.

Many growers overlook depreciation and interest costs. Depreciation is an indication of when the irrigation system will wear out. California suggests a 10-year life expectance for drip and 20 years for a concrete pipeline and valve system (3). The oldest drip systems in the Valley are now approximately 5-years old. Systems which used polyethylene tubing of the proper formulation still are in good condition and a 10-year life seems reasonable for such tubing. The underground PVC pipe should last more then 10 years. Concrete pipeline systems have functioned well for 20 years with regular maintenance.

**Table 3.** Operating costs per acre for drip and flood irrigation for selected years of operation.

| | Drip irrigation | | | | Flood irrigation | | | |
|---|---|---|---|---|---|---|---|---|
| Item/year | 1st | 2nd | 3rd | 6th (+) | 1st | 2nd | 3rd | 6th (+) |
| Labor[1] | $16.00 | $16.00 | $16.00 | $16.00 | $20.00 | $16.00 | $20.00 | $20.00 |
| Electricity[2] | 6.56 | 7.57 | 15.07 | 16.81 | — | — | — | — |
| Repairs[3] | 11.00 | 11.00 | 11.00 | 11.00 | 5.04 | 5.04 | 5.04 | 5.04 |
| Water[4] | 1.42 | 2.32 | 6.96 | 14.62 | 15.00 | 12.00 | 15.00 | 15.00 |
| Fertilizer application | — | — | — | — | 5.00 | 5.00 | 5.00 | 5.00 |
| Out-of-pocket total | $34.98 | $36.89 | $49.03 | $58.43 | $45.04 | $38.04 | $45.04 | $45.04 |
| Depreciation[5] | 55.00 | 55.00 | 55.00 | 55.00 | 25.20 | 25.20 | 25.20 | 25.20 |
| Interest[6] | 44.32 | 44.32 | 44.32 | 44.32 | 41.92 | 41.92 | 41.92 | 41.92 |
| Total | $134.30 | $136.21 | $148.35 | $157.75 | $112.16 | $105.16 | $112.16 | $112.16 |

[1]Assumes 8 hr per acre per year at $2 per hr to check drippers, blow headers, and laterals. Flood irrigation labor assumes 10 strip irrigations the first year at 1 hr per acre, eight strip irrigations the second year, and from the third year on five full irrigations at 2 hrs per acre.

[2]Assumes declining charge per kwh on general service rate charged by Central Power and Light Company.

[3]Repairs assume 2 and 1% of initial investment per year for drip and flood systems, respectively.

[4]Assumes $.02 per 1,000 gal for drip, $3 per acre for flood with strip irrigation charged at one-half the acreage.

[5]Assumes straight-line depreciation with no salvage value and 10-year life on the drip system and 20-year life on the flood system.

[6]Assumes an 8% interest charge on the initial investment.

## EXTENUATING CIRCUMSTANCES

There are situations in which drip irrigation has definite advantages over flood irrigation. For instance, some older orchards that were never leveled require cross-check borders between every few trees and in extreme cases between every tree. Irrigation labor in such orchards can be two or three times that needed in a level orchard with a properly designed flood system. In unleveled orchards, low areas are often over-watered, while high areas do not get sufficient water. These difficulties can be overcome with drip irrigation.

Many owner-operators of modest acreage prefer the labor involved in drip systems to the often arduous "boot and shovel work" that can be involved in flood irrigation.

A possible benefit of drip irrigation not yet established by research or grower experience, is as a hedge against drought. In times of water shortage about the only way to stretch the allocated water supply under flood irrigation is to extend the period between waterings. A drip system operated on a schedule similar to that given in Table 1 but in lesser amounts might avoid extended periods of moisture stress.

The ready access to the orchard under drip irrigation can be an occasional benefit. Since the middles are not wetted, machine operations such as insecticide spraying do not have to be scheduled around irrigations.

There are situations where the cost of drip irrigation would exceed the benefits it provides. An established orchard that is level and easily irrigated by surface flooding is not a prime candidate for a drip irrigation system. The investment cost in drip irrigation would likely have little monetary reward. Even if the orchard was somewhat difficult to irrigate by flood irrigation, an investment in drip irrigation may not be profitable. Improving the efficiency of the existing flood system by shortening the length of water run, irrigating from a different side of the orchard, or simply abandoning part of the orchard may be a more profitable alternative.

Installation of a drip system in an old orchard may bring about problems in replacing the orchard a few years from now. Uprooting the trees will likely damage or destroy the underground pipe of the drip system. The lateral lines will have to be salvaged and relaid when the new orchard is planted.

## SUMMARY

Drip irrigation provides a substantial savings of water in newly planted orchards, but as trees grow, water requirements are about the same under either drip or flood irrigation (2).

The investment costs are quite comparable for drip and pipeline systems. If a storage reservoir is required of if elaborate filtration is needed, the cost of developing a drip system will likely exceed the cost of a pipeline installation for flood irrigation at current prices.

The savings associated with a drip system are achieved during the first years of an orchard's existence. The labor involved in maintaining and cleaning the drip system is likely to be comparable to the irrigation labor required in a leveled orchard. Furthermore, part of the labor energy saved in drip irrigation is simply transferred to an electrical energy expenditure. Electrical costs may run high if the drip system is not engineered to deliver the required amount of water at a minimum electrical usage.

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# Protein Yields from *Brassica carinata*

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## ABSTRACT

The juice of *Brassica carinata* was extracted by the use of a sugarcane roller mill and by comminuting the plants and expressing the juice with a hydraulic rack and cloth press. Juice yields were higher (67%) from the comminuted plants than from the roller milled plants (30%). The yield of crude protein coagulum was higher (1.80%) in the juice from the comminuted material than in juice from the sugarcane roller mill (1.27%). Quality of the crude protein coagulum from juice expressed by the two processes was not substantially different. Protein lipid and carotene levels were slightly higher in the crude coagulum from the comminuted plants while ash levels were higher in that from the juice of the roller milled plants. The use of sugarcane roller mill would allow simple recovery of the pressed plant material for possible feed uses.

The green leaves of plants are a good source of protein, but few leafy green foods are consumed directly as primary sources of protein (7, 10). The selection of plant proteins ingested by humans, and certain monograstic animals, is limited by fiber content and toxic factors of plants (2). Many of these plants, however, might be successfully exploited as sources of easily extracted food protein (2, 4, 6, 7, 8).

Potentially useful species of plants as sources of plant protein concentrate require careful evaluation (7). *Brassica carinata* was introduced to this country from Ethiopia in 1957 and assigned Plant Introduction No. 243913. This plant was grown for the first time in the Southwest during the winter season of 1967-68 and was intended as an oil seed crop. The lush, tender vegetative grown, however, led to its favorable evaluation as a leafy green vegetable crop for fresh, canned or frozen products. (11). Evaluation of the protein isolated from the juice of this vegetable by Brown et al. (4), established the plant as a potential source of protein. The vegetable was given the name of TAMU-TexSel and released as a vegetable crop by Texas Agricultural Experiment Station (5).

The process of recovery of plant juice protein basically consists of: harvest of plants; removal of juice by cell disrupture or other methods; coagulation of protein by heat, solvents, or pH adjustment; and collecting and drying the protein coagulum. Juice may be expressed by grinding the plant and pressing in roller mills similar to the mill used by Knuckles et al. (8). That method allows recovery and use of the plant residue as an animal feed which could help make the production of plant juice protein economical as suggested by Knuckles et al. (8) and Bray (3). The purpose of this study was to determine the yield and quality of protein as related to method of juice expression.

## EXPERIMENTAL

The *Brassica carinata* used in this study was grown by the Texas Agricultural Experiment Station, Weslaco, Texas. Triplicate random samples from 10-foot segments of 40-inch rows were cut by hand to 1 or 2 inches above the ground on the 55th and 56th day after planting. They were immediately trimmed, weighed and processed. The first set of samples was ground with a Model D Fitzmill comminuting machine (The W. J. Fitzpatrick Co., Chicago, Ill.) equipped with a .064-inch screen. (Mention of company or trade name does not imply endorsement by the United States Department of Agriculture over others not mentioned.) The juice was pressed from the comminuted material with a hydraulic rack and cloth press; pressure was gradually increased to 4,000 psi and held for 10 minutes. The juice was extracted from the second set of samples with a sugarcane roller mill similar to that used by Knuckles et al. (8), and was filtered through 3 layers of cheesecloth. Protein coagulum was prepared as quickly as possible, usually within 1 hour, after juice extraction.

Samples for whole plant analyses were taken from each of the freshly cut samples at time of harvest. These samples were hand chopped, dried in a forced-draft oven at 50°C, ground in a Wiley Mill equipped with a .073-inch screen, and redried to a constant weight at 70°C under vacuum prior to analyses. Dry matter was determined on other samples taken at harvest according to the official A.O.A.C. methods (1).

For determination of specific gravity, 1 liter of juice was weighed in a tared volumetric flask, Crude protein coagulum was prepared from each sample by heating 1 liter (1022 g) of juice to 70°C and holding overnight at 4°C. The supernatant was decanted, and the final liquor was removed by filtering the coagulum through Whatman No. 1 filter paper. The coagulum was freeze-dried, ground with a mortar and pestle, dried in a vacuum oven at 70°C to constant weight, and stored until analysis.

Kjeldahl nitrogen, determined by A.O.A.C. methods (1), was converted to protein by multiplying by 6.25.

Lysine was determined by enzymatically digesting 100 mg of sample of coagulum with 5 mg of Pronase (Cal BioChem, La Jolla, Calif.) and reacting the sample with 2-chloro-3,5-dinitropyridine (12).

Xanthophyl and carotene levels in the protein coagulum were determined spectrophotometrically by the method of Kohler et al. (9).

Ash and ether extracts were determined by A.O.A.C. methods (1).

## RESULTS AND DISCUSSION

Plant yields, moisture and protein levels in the plants, juice, coagula and protein yields appear in Table 1.

The plant yield per acre, protein and moisture levels were not different on successive days. Stage of maturity indicated that protein levels in the plants reached a maximum just prior to the formation of seed heads (4), 55 to 56 days after planting.

**Table 1.** Yield characteristics of *Brassica carinata* pressed with a hydraulic press or roller mill.

| | Sugarcane Roller Mill | Hydraulic Press |
|---|---|---|
| Plant Yield (tons/acre) | 14.1 | 13.2 |
| Protein in Plant (%) | 27.7[1] | 27.8 |
| Moisture in Plant (%) | 90.1[2] | 90.6 |
| Juice Yield (%) | 30.0 | 67.0 |
| Specific Gravity (g/ml) | 1.022 | 1.022 |
| Coagulum Yield (%) | 1.27 | 1.80 |

1 Dry weight basis.

2 Moisture in plant at the time the juice was expressed.

Juice yields differed considerably between the two methods of expression, and were 67% of the fresh plant weight with a Fitzmill comminuting machine and hydraulic press and 30% with a sugarcane roller mill. Results with the sugarcane roller mill were comparable to those obtained with alfalfa by Knuckles et al. (8) using a similar mill. The large quantity of plant juice extracted by the machine and press method was due to disruption of the plant matrix and to application of 4,000 psi for 10 minutes. Furthermore, the whole plants were passed through the sugarcane roller mill only once; additional passes through the machine probably would have expressed additional liquid.

**Table 2.** Analyses of *Brassica carinata* plant juice protein coagulum following juice extraction with a sugarcane roller mill or hydraulic press.

| Component | Sugarcane Roller Mill | Hydraulic Press |
|---|---|---|
| Protein (%) | 50.6 | 69.3 |
| Ether Extract (%) | 4.4 | 7.7 |
| Ash (%) | 19.0 | 11.0 |
| Lysine (g/100 protein) | 6.4 | 7.0 |
| Xanthophyl (mg/100 g coagulum) | 76.3 | 79.2 |
| Carotene (mg/100 g coagulum) | 41.5 | 50.9 |

Values in table were based on duplicate determinations on triplicate samples, dry weight basis. Lysine values are percent lysine in the protein present in the coagulum.

Data from chemical analyses of the crude protein coagulum are presented in Table 2. Coagulum yield was greater (1.80%) from the comminuted material with the hydraulic press than from the sugarcane roller mill (1.27%). Protein levels of the coagulum showed a similar trend. Protein level of the coagulum was 69.3% from the hydraulic press plants and 50.6% from the sugarcane roller mill which indicated that the degradation of the plant tissue allowed extraction of a large proportion of the juice protein. Of the total protein in the plants, the hydraulic press method yielded 48% and the roller mill 23%. The protein levels in this study are slightly higher than those obtained from alfalfa by Knuckles et al. (8) at 17% using a similar sugarcane roller mill. Those authors used a twin-screw pressing technique for the ground plant material, and juice from that method yielded slightly less protein than juice from the hydraulic press. A wide range of protein yields was reported by Betschart and Kinsella (2) for plants of different species extracted by different techniques.

Lipid levels in the crude protein coagulum were lower from juice expressed by the roller mill (4.4%) than from juice expressed by hydraulic press (7.7%). These results are slightly higher than the results of Knuckles et al. (8) who reported lipids levels in alfalfa protein coagulum 1.4% and less.

Levels of xanthophyl and carotene in the crude protein coagulum differed little between the juices expressed by the two processes. Xanthophyl and carotene contents in mg per 100 g of coagulum were 79.2 and 50.9, respectively, from the hydraulic press and were 76.3 and 42.5, respectively, from the roller mill.

Ash level in the crude protein coagulum was 19.0% from the sugarcane roller mill and 11.0% from the hydraulic press material. These values are in general agreement with those obtained from alfalfa protein coagulum with a sugarcane roller mill by Knuckles et al. (8) which had an ash content of 16.7%.

In protein lysine level is often used as an indicator of quality. Brown et al. (4) showed that the lysine levels in *Brassica carinata* plant juice protein were similar to published values for alfalfa, soybean and other plant proteins. Lysine value in the protein was not affected by the method used for expression of the juice.

No experimental data are available on feeding the plants material leaves or protein coagulum to livestock or feeding the residue from the sugarcane roller milled material. Since the cultural conditions of this crop are very similar to those for spinach, it could be machine harvested. Furthermore, this crop can be used as a vegetable as suggested by Stephens et al. (11). Should the crop mature beyond the stage suitable for use as a vegetable, it might be harvested for extraction or protein and the refuse used as a green-cut forage.

In conclusion, the sugarcane roller mill can be used to express the juice from *Bassica carinata* for the purposes of isolating a carotenoid-rich protein concentrate. The yields of juice and protein from the juice were lower from the roller mill than from the hydraulic press, however. The residue from the roller mill contained protein and could easily be recovered for use as feed. The quality of the protein was not substantially different from the juices expressed by the two processes and yields a crude protein rich in carotenoids for possible inclusion in feed formulations. Further purifications might yield a protein suitable for human consumption.

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## Computer-aided Inventory of Sugarcane in Hidalgo County, Texas, Using LANDSAT-1Data

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## ABSTRACT

Earth Resources Technology Satellite (LANDSAT-1) multispectral scanner (MSS) data of fields in the agricultural landscape for a December 11, 1973, overpass (Scene I.D. 1506-16293) were used to estimate the sugarcane (*Saccharum officinarum* L.) hectarage in Hidalgo County, Texas. The computer-aided estimate of 8,900 ha (22,100 acres) was 8% larger than the Texas Crop and Livestock Reporting Service estimate of 8,300 ha (20,500 acres) for the 1973 production and harvest season. Although harvested sugarcane fields were identified as bare soil and some citrus and native vegetation were mistakenly identified as sugarcane, the known location of sugarcane fields in the county compared favorably with their location on a computer generated thematic classification map. In the fall, before much sugarcane is harvested, is a good time to make such a survey since other plants, except citrus and some native trees, have less dense canopies than do sugarcane, hence dissimilar spectral signatures.

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This study tests the effectiveness of a computer-aided inventory of sugarcane (*Saccharum officinarum* L.) in Hidalgo County, Texas, as part of ongoing remote sensing research, using information from the first Earth Resources Technology Satellite (LANDSAT-1). Sugar producers keep detailed inventories of sugarcane hectarage in the Rio Grande Valley; hence the need for automated satellite inventory is probably not as great for sugarcane as for other crops. However, the potential of computer-aided inventories for other kinds of crop conditions, like citrus, combined cotton and sorghum, and vegetable, has been previously demonstrated (1), where computer estimates differed by 32, 8, and 47%, respectively, from Texas Crop and Livestock Reporting Service (2) hectarage estimates. The objective of our study was to use the existing detailed sugarcane inventory, for the 1973 production and harvest season, as a standard for further measuring the potential for computer-aided LANDSAT crop and soil condition inventory procedures. Therefore, the total hectarage of sugarcane fields in Hidalgo County, determined from LANDSAT-1 data, was compared with the hectarage reported by the Texas Crop and

Livestock Reporting Service (obtained from valley sugar producers) to determine the accuracy of computer aided LANDSAT sugarcane hectarage inventories.

## MATERIALS AND METHODS

The experimental site chosen for hectarage inventory of sugarcane was Hidalgo County, Texas, because most valley sugarcane is grown in this county. The December 11, 1973, LANDSAT-1 overpass (Scene I.D. 1506-16293) provided multispectral scanner (MSS) data samples (spectral signatures of the agricultural landscape) recorded on four computer compatible tapes (CCT) for a 185- by 185-km area that included Hidalgo County (Fig. 1). A distribution map (Fig. 2) showing the known location of sugarcane in the county was used as a reference for testing the success of the LANDSAT computer-aided sugarcane hectarage inventory.

Satellite MSS data from representative crop, soil, and water areas in the county (less than 0.2% of the total MSS digital data in the county) were selected to train an IBM 1800 computer (1) to classify MSS data samples recorded on the CCT from Hidalgo County into five land use categories: sugarcane, McAllen-Brennan soil associations, Harligen-Benito soil association, other vegetation (mainly citrus and rangeland), and water.

Computer estimated hectarage of all five land use categories, including sugarcane, is based on classification of every LANDSAT MSS data sample in the county (about 850,000 samples). Visual evaluation of sugarcane classification results was facilitated using a line printer thematic classification map (Fig. 3).

## RESULTS AND DISCUSSION

The enlarged LANDSAT-1 infrared black-and-white positive print (MSS 7; 0.8 to 1.1 um band of MSS) of Hidalgo County (Fig. 1), depicts sugarcane fields as dark areas. Figure 2 is a map, supplied by Cowley Sugar House in Santa Rosa, Texas, showing the distribution of sugarcane fields in Hidalgo County. In Figure 1 there are some dark areas (falsely indicating sugarcane fields) in both the western and northeastern parts of the county that are not explainable by the sugarcane distribution map (Fig. 2). Color composites (not shown) of LANDSAT-1 imagery from MSS 5, 6, and 7 (0.6 to 1.1 um) of the county depict sugarcane fields as orange-red areas that better match the sugarcane distribution map. We included the black-and-white print shown here to orient the reader, even though discerning features is not as easy as with color composite imagery.

The computer hectarage estimate (Table 1), developed during the computer-aided survey, was 8,900 ha (22,100 acres) compared with the

Texas Crop and Livestock Reporting Service (2) estimate of 8,300 ha (20,500 acres), an 8% overestimation. However, some sugarcane fields were harvested before the December 11, 1973, overpass, causing omission errors that tended to underpredict sugarcane hectarage. The computer falsely counted some other areas in the county as sugarcane that had sugarcane spectral characteristics, a commission error that tended to overestimate sugarcane hectarage. The overall result was a cancellation of errors that yielded a computer-aided estimate of sugarcane hectarage near the reported sugarcane hectarage estimate. The 8% overestimate difference compared favorably with previously reported hectarage estimate differences for citrus, combined cotton and sorghum, and vegetables of 32, 8, and 47%, respectively (2).

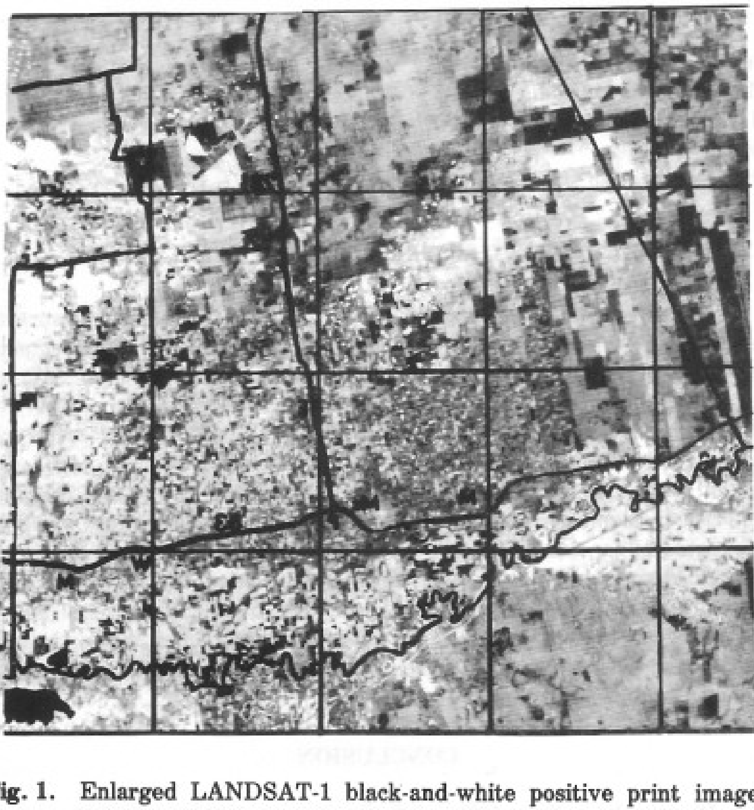

**Fig. 1.** Enlarged LANDSAT-1 black-and-white positive print imagery (MSS 7; 0.8- to 1.1-um band) depicting sugarcane in Hidalgo County, Texas, as darkest tones and water bodies as lightest tones. Superimposed on the image are an outline of the county, latitude and longitude coordinates, the Rio Grande, and highways 83 and 281.

**Table 2.** Comparison of computer sugarcane estimated hectarage to ground truth estimated hectarage (Texas Crop and Livestock Reporting Service( within Hidalgo County for the 1973 to 1974 growing season. Computer hectarage estimates for soil, water, and other categories are also given although no other reported estimates are available for comparison. Computer estimates are based on a December 11, 1973, LANDSAT-1 overpass.

| Category | LANDSAT estimate (ha) | Texas Crop and Livestock Reporting Service estimate (ha) |
|---|---|---|
| Sugarcane | 8,900 | 8,300 |
| McAllen-Brennan soil | 70,500 | -- |
| Harlingen-Benito soil | 46,600 | -- |
| Water | 4,000 | -- |
| Other vegetation | 284,000 | -- |
| Total | 414,000 | -- |

Information currently available does not permit us to measure the magnitude of the omission and commission errors, but when we compared the location of sugarcane fields in Hidalgo County (Fig. 2) with the sugarcane thematic map (Fig. 3), generated by the computer, there were some errors. Even though errors may be present, overall classification seems good because many of the sugarcane fields marked on the county ground truth map (dark areas) could be identified on the county computer generated thematic map (darkest appearing line printer symbols). Harvested sugarcane fields probably appeared as loamy and sandy soils (like McAllen-Brennan soil associations; /) or as loamy and clayey soils (like Harlingen-Benito soil associations; —). One area falsely identified as sugarcane on the computer-generated thematic map appeared northeast of Delta Lake (*). Citrus and rangeland appeared as blank areas on the thematic map.

## CONCLUSION

Our results indicated that omission errors could have been decreased if LANDSAT-1 or -2 MSS data were collected just before the beginning of the fall sugarcane harvests in October (harvesting is from October through March). Not only would most sugarcane fields still be mature and unharvested at this date, but the spectral signature of other plants, except citrus and native trees, would most likely be different because of less dense canopies. Consideration of crop harvesting dates would benefit LANDSAT inventory accuracy of other crops as well.

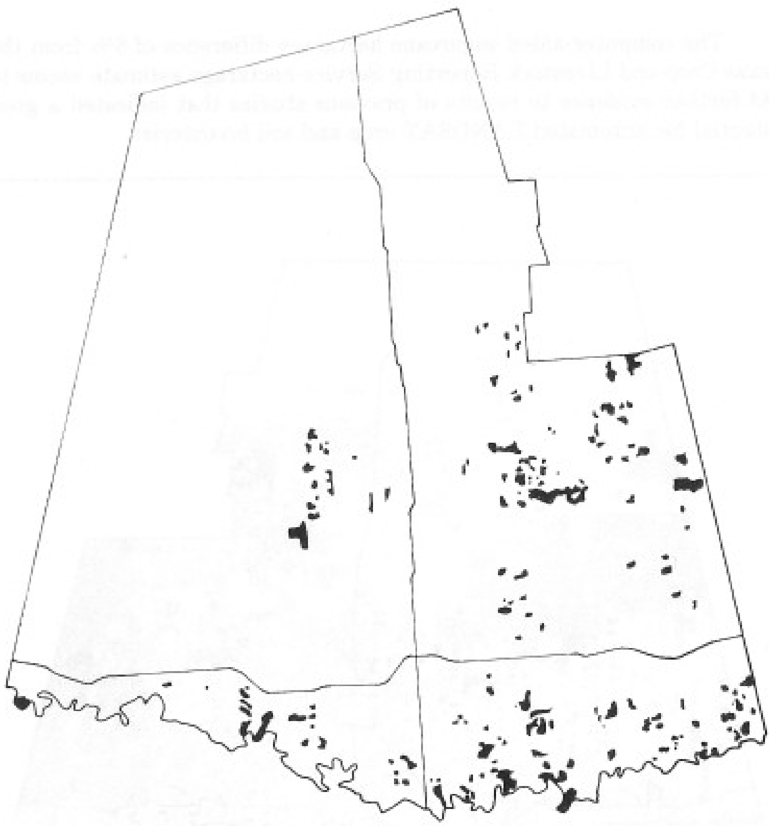

**Fig. 2.** Distribution map showing sugarcane locations in Hidalgo County, Texas, for the 1973 sugarcane production and harvest season.

Furthermore, commission errors could be decreased by using earth coordinate location (latitude and longitude) of sugarcane fields that could be correlated with LANDSAT digital data CCT coordinates. By making general surveys of only cultivated areas of the valley, defined in terms of earth coordinates, the chance of falsely classifying nonsugarcane areas (like dense native rangeland brush) as sugarcane would be decreased. For detailed surveys of sugarcane, the inventory could be made to correspond with sugarcane field survey plots already used by sugar producers at the Cowley Sugar House in Santa Rosa, Texas. Using such a detailed system, sugarcane fields could be classified at other times of year for iron chlorosis, general crop vigor, and probable yeild categories.

The computer-aided sugarcane hectarage difference of 8% from the Texas Crop and Livestock Reporting Service hectarage estimate seems to add further evidence to results of previous studies that indicated a good potential for automated LANDSAT crop and soil inventories.

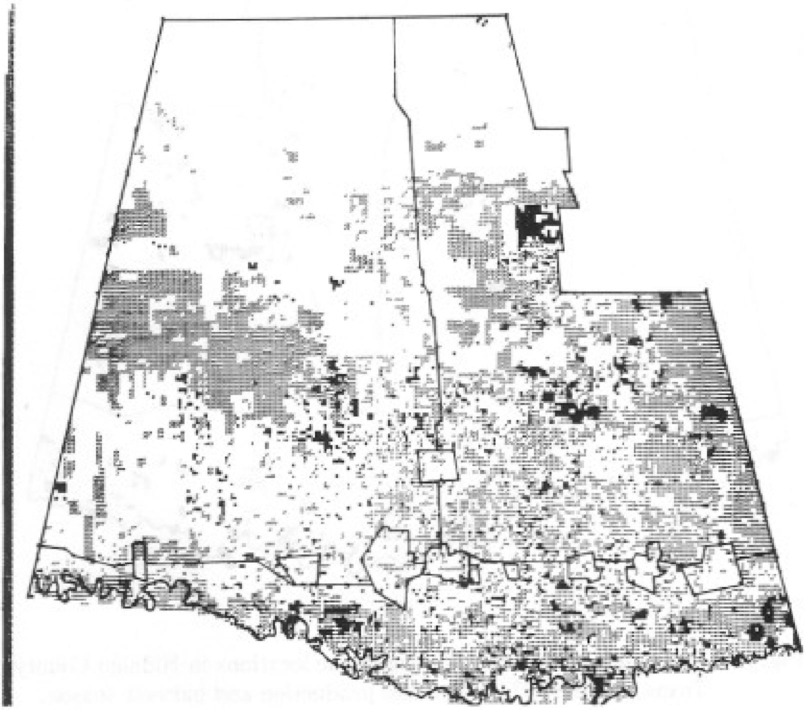

**Fig. 3.** Hidalgo County, Texas, computer-generated thematic classification map (based on a December 11, 1973, LANDSAT-1 overpass using MSS bands 5, 6, and 7) shows sugarcane as darkest appearing line printer symbols (M over printed W) and McAllen-Brennan soil associations, Harlingen-Benito soil associations, other vegetation, and water as the lighter appearing line printer symbols "/", "—", "space", and "·", respectively.

## ACKNOWLEDGEMENT

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## Spectrophotometric Reflectance Differences Between Dead Leaves and Bare Soils

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### ABSTRACT

Reflectance differences between dead leaves and bare soils were characterized by measuring spectrophotometric reflectance in the laboratory over the 0.5- to 2.5-um waveband for dead leaves from six crops [avocado (*Persea americana* Mill.), citrus [*Citrus sinensis* (L.) Osbeck], corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), sorghum [*Sorghum bicolor* (L.) Moench.], and sugarcane (*Saccharum officinarum* L.) and for the respective bare soils next to the place where the dead leaves were lying on the ground.

Reflectance differences between the dead leaves of five of the six crops and the respective bare soils were largest (15.3 to 24.5 percentage points) within the near-infrared waveband (0.75 to 1.35 um) except for sugarcane whose largest reflectance difference was 19.2 percentage points at the 1.9-um wavelength; however, the difference was 18.7 percentage points at the 0.85-um wavelength within the near-infrared waveband. Thus, this waveband should be the best spectral region to distinguish dead leaves (leaf litter) from bare soils.

Using field spectroradiometric measurements, at the 0.5- to 1.8-um waveband, we (2) have shown that crop residue littered on the soil surface had a higher reflectance than bare soil, but standing crop residue had lower reflectance than bare soil. Consequently, we have been asked, "what is the reflectance difference between a dead leaf and a bare soil?" This question has been answered partially in that corn leaves with a low water content (3 to 18%) had 10 to 30 percentage points more spectrophotometrically measured reflectance than did a dry clay soil (water content of 3 to 6%) over the 0.5- to 2.5-um waveband (3). However, further study is needed to more fully understand the difference.

The objective of this study was to characterize reflectance differences between dead leaves of six crops and the respective bare soils next to the place where the dead leaves were lying on the ground by spectrophotometrically measuring reflectance in a laboratory over the 0.5- to 2.5-um waveband. In this paper, dead leaves are considered vegetation devoid of chlorophyll with much lower water content than living tissue. Such leaves are yellow or "bleached," dry, and brittle. They may be naturally senescent leaves still attached to either live or dead plants such as mature wheat and corn, naturally shed leaves, and dry leaves resulting from physical damage such as a hail and mowing or from physiochemical damage such as freezing and extreme drought. Under field conditions, the term dead leaves may cover "stubble" and crop residues of those plants whose living stems, leaf sheaths, and petioles contained chlorophyll.

## MATERIALS AND METHODS

A Beckman Model DK-2A spectrophotometer (Beckman Instruments, Inc., Fullerton, CA), equipped with a reflectance attachment, was used to measure the total diffuse reflectance for five replications of soils and dead crop leaves. (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U.S. Department of Agriculture over others that may be commercially available.) Data were recorded at discrete 0.05-um intervals over the continuously measured 0.5- to 2.5-um waveband (41 wavelengths). Data were corrected for decay of the $BaSO_4$ standard to give absolute radiometric data (1).

Five intact dead leaves were selected from the littered residue of six crops [avocado (*Persea americana* Mill.), citrus (*Citrus sinensis* (L.) Osbeck), corn (*Zea mays* L.) cotton (*Gossypium hirsutum* L.), grain sorghum (*Sorghum bicolor* (L.) Moench.), and sugarcane (*Saccharum officinarum* L.)] for spectrophotometric reflectance measurements. Each brittle, "bleached," and partially dehydrated leaf was placed over the spectrophotometer's port for reflectance measurements. Average water contents on a dry-weight basis for avocado, citrus, corn, cotton, grain sorghum, and sugarcane leaves were 6.3, 11.8, 8.0, 15.0, 4.7, and 9.7%, respectively.

Avocado, citrus, cotton, grain sorghum, and sugarcane leaves were lying on a Hidalgo sandy clay loam soil, corn leaves were lying on a Hidalgo clay loam soil. The bare surface soil, next to where the leaves were collected, was sampled to about a 1-cm depth for each crop. Average soil water contents on a dry-weight basis were 2.3, 6.8, 5.1, 5.3, 3.9, and 5.4% for soils for avocado, citrus, corn, cotton, sorghum, and sugarcane leaves, respectively. Laboratory spectrophotometric reflectance measurements were made on five subsamples of each composite soil sample. Soils were hydraulically pressed into bottle caps so that samples could be mounted vertically over the spectrophotometer's port (4); noncompacted soil would have fallen into the spectrophotometer's integrating sphere.

Water content of soils and leaves was determined on samples oven dried at 68C for 72 hr and cooled in a desiccator before weighing.

The reflectances for the soil and leaves of each crop were analyzed for variance (5). The least significant difference (LSD, P = 0.01) was used to test the mean difference between soil and leaves for each crop at each of 41 wavelengths.

## RESULTS AND DISCUSSION

The reflectance of dead sugarcane leaves was significantly (P = 0.01) greater than the bare soil reflectance at all wavelengths measured (Fig. 1). The reflectances of dead avocado leaves and the bare soil were statistically alike at 0.70-, 0.75-, 1.90-, 1.95-, 2.00-, 2.05-, 2.15-, 2.20-, and 2.25-um wavelengths; for citrus at the 0.65-, 1.70, and 1.75-um wavelengths; for corn at 0.50- and 0.55-um wavelengths; for cotton at 0.60-, 0.65-, 2.25-, 2.30-, 2.35-, 2.40-, 2.45-, and 2.50-um wavelengths; and for sorghum at the 0.55- and 0.60-um wavelengths. At all other wavelengths, reflectances of these leaves were statistically different than respective soil reflectances.

The largest reflectance difference in percentage points (PP) between dead leaves and bare soil and the corresponding wavelength for each crop (Fig. 1) were: avocado, 15.7 PP, 1.05 um; citrus, 15.3 PP, 0.95 um; corn, 24.5 PP, 1.3 um; cotton 18.1 PP, 1.00 um; grain sorghum, 22.1 PP, 0.95 um; and sugarcane, 19.2 PP, 1.9 um. Except for sugarcane, the reflectance differences between dead leaves and bare soils were greatest on the near-infrared plateau over the 0.75- to 1.35-um waveband. On the near-infrared plateau, the largest reflectance difference between sugarcane leaves and soil was 18.7 PP at the 0.85-um wavelength.

These results may be valuable in the future for using sensors on board aircraft or spacecraft to predict wind erosion susceptibility of Rio Grande Valley soils that are used for horticultural crop production.

## CONCLUSION

Laboratory spectrophotometric results indicated that the 0.75- to 1.35-um waveband should be the best spectral region for distinguishing dead leaves from bare soils. Within this waveband, reflectance differences between dead leaves and bare soils for six crops ranged from 15.3 to 24.5 percentage points. However, under field conditions, dead leaves are superimposed on the soil background's reflectance; thus, a composite reflectance is sensed. Duplicating field soil surface conditions in the laboratory is also difficult, since the soil surface usually becomes smoother and lighter colored with time after tillage. Nevertheless, the laboratory data represented pure reflectance from bare soils and dead leaves and indicated useful wavelengths for distinguishing dead leaves from bare soils.

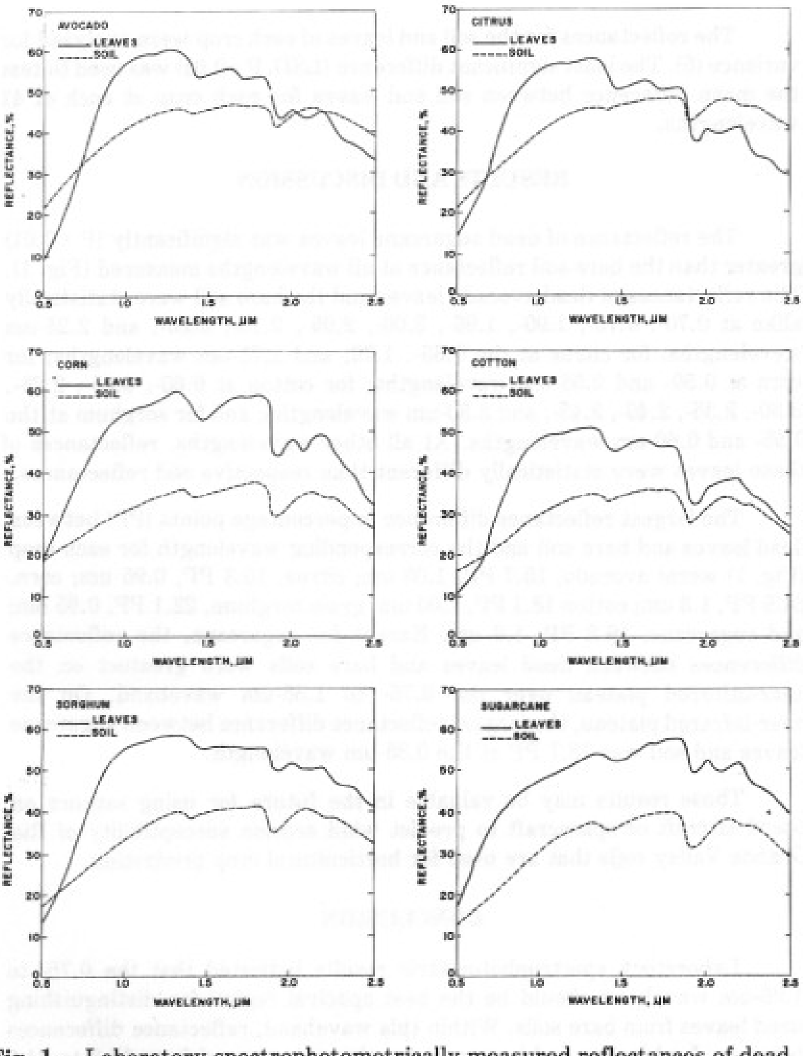


**Fig. 1.** Laboratory spectrophotometrically measured reflectances of dead leaves and bare soils for avocado, citrus, corn, cotton, sorghum, and sugarcane crops over the 0.5- to 2.5-um waveband.

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The spectral reflectance contrast between dead leaves and bare soils found in this study suggests that efforts should be made to relate aircraft and spacecraft spectral data to estimated (or measured) amounts of crop residue standing or littered on the soil surface for several test fields in various locations. If the amount of residue can be estimated spectrally, then the already established principle that crop residues reduce wind or water erosion susceptibility of soils can be used.


## ACKNOWLEDGEMENT

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**Discovery of Candelilla (*Euphorbia antisyphilitica* Zucc.) in the Lower Rio Grande Valley of Texas**

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## ABSTRACT

Candelilla, a succulent grown in cactus gardens, has recently been discovered as a member of the native flora of the Lower Rio Grande Valley of Texas. A colony of this species, about 10 acres in size, has been located in the brush country north of Roma in Starr County, Texas.

Candelilla, also known as wax euphorbia, is frequently grown as a succulent in cactus gardens in the southwestern United States (Fig. 1). This plant is also used as a source of wax in Mexico (4). Candelilla has recently been discovered as a member of the native flora of the Lower Rio Grande Valley. About a 10-acre colony of this species was discovered (fall, 1974) growing in the brush country 9 miles north of Roma, Starr County, Texas. We collected and pressed specimens that are represented by herbarium samples in the Biology Department at Pan American University, Edinburg, Texas, and in the Range Herbarium at the USDA laboratory in Weslaco, Texas.

Correll and Johnston (2) indicated that candelilla is a Chihuahuan Desert species and that it had been found growing only in the Trans-Pecos area of Texas and south through the Chihuahuan Desert of Central Mexico (in the states of Chihuahua, Coahuila, Durango, Nuevo Leon, Hidalgo, San Luis Potosi, and Zacatecas). Recently it was discovered for the first time near Laredo in Webb County, Texas (Personal Communication: Dr. Marshall C. Johnston, Herbarium and Department of Botany, The University of Texas at Austin, 78712).

The Roma location where candelilla has been discovered is a clay loam range site. The major soil type here is a Garceño clay loam which is characterized by having a high lime content, thus it is very droughty. We used line transects (1) and a point frame (3) to obtain the associative species composition of the native vegetation in the immediate area of the candelilla colony, which is dominated by woody species with little herbaceous understory. Dominant woody species are guajillo (*Acacia berlandieri* Benth.), blackbrush (*Acacia rigidula* Benth.), coma (*Bumelia celastrina* H. B. K.), coyotillo [*Karwinskia humboldtiana* (R. & S.) Zucc.], prickly pear cactus (*Opuntia lindheimeri* Engelm.), guayacan [*Porlieria angustifolia* (Engelm.) Gray], mesquite (*Prosopis glandulosa* torr.), and lotebush [*Ziziphus obtusifolia* (T. & G.) Gray]. Dominant grasses are red grama (*Bouteloua trifida* Thurb.), Texas Bristlegrass (*Seataria texana* W. H. P. Emery), and slim tridens [*Tridens muticus* (Torr.) Nash].

This, as well as several other unique species in South Texas, should be preserved since they are threatened by extermination through the massive bulldoze-clearing of native brushland to obtain more forage growing area for grazing.

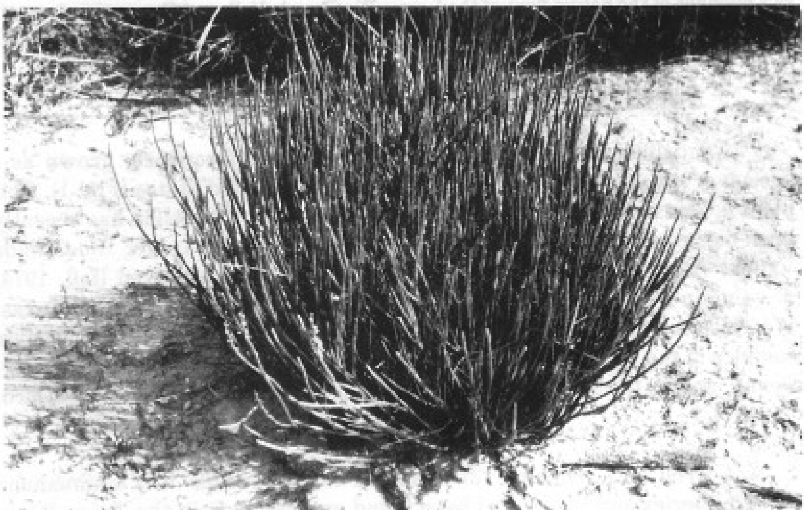

**Fig. 1.** A mature plant of candelilla (*Euphorbia antisyphilitica* Zucc.) growing north of Roma, Starr County, Texas.


## ACKNOWLEDGEMENTS

The authors thank Herbert A. Treviño for bringing the discovery of candelilla to their attention, and Dr. Robert Lonard, Pan American University, Edinburg, Texas, for confirming the identification of the species.

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## Native Plant Thought Extinct Grown as an Ornamental

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### ABSTRACT

Jopoy (*Esenbeckis berlandieri Baill.*), a tree belonging to the citrus family, is a presumably extinct member of the native flora of the Lower Rio Grande Valley of Texas. However, it is being grown as an ornamental at several residences in the Lower Rio Grande Valley, and efforts are being made to reestablish it as a native plant.

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Jopoy, also known as Runyon *esenbeckia*, is a tree that is a member of the citrus family: *Rutaceae*. It reaches a maximum height of about 20 ft. It has large aromatic, dark-green, trifoliate leaves (Fig. 1), the flowers are small and cream-white and its fruit are small five-lobel capsules (2).

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**Fig. 1.** Photo of the leaves and flowers of the Jopoy tree.

Jopoy, as native tree of Mexico, was a member of the Lower Rio Grande Valley's native flora. Four Jopoy trees were growing on the banks of the Resaca Vieja, 3 miles northeast of Los Fresnos, Cameron County, Texas (1,2). This locality has since been cleared of most native vegetation; thus, Jopoy was presumably eliminated from our native flora.

The late Robert Runyon of Brownsville, Texas, a botanist who studied the flora of South Texas, obtained Jopoy seeds from the trees growing at Los Fresnos in 1929 and grew a beautiful specimen in his garden which survives today. The specimen has served as the seed source for establishing this species at other locations in the Lower Rio Grande Valley.

Jopoy is now grown as an ornamental at several residences in Cameron County. Ivan Shillers of Brownsville recently grew over 100 young trees from seeds. Many of these plants have been transplanted to Santa Ana National Wildlife Refuge south of Alamo, Texas, and to Bentsen State Park near Mission, Texas, to reestablish the Jopoy as a member of our native flora. Several specimens have been grown in a greenhouse at the USDA laboratory in Weslaco, Texas, and transplanted to residences in Hidalgo County, Texas.

Hopefully, Jopoy will be reestablished as a member of the unique native flora and will become a valuable and aesthetic ornamental in the Lower Rio Grande Valley of Texas.


## ACKNOWLEDGEMENT

The author thanks Mrs. Robert Runyon for historical information and for permission to photograph the Jopoy tree.


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## Eastman Kodak E-4 Processing at 100°F Using Spiral Reels

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### ABSTRACT

A process has been developed that shortens darkroom time to 16 minutes for processing Eastman Kodak Ektachrome-X, Ektachrome Type B, and Ektachrome High Speed films—a saving of 34 minutes over prescribed routines. This is accomplished by increasing the temperature of processing solutions from 85° to 100°F using spiral reels. Continuous agitation is required, and rapid film transfer from one solution to the other is necessary for satisfactory photographic results. However, if instructions are followed, the color balance is stable, and the emulsion is of high quality.

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We have increased the temperature of processing solutions from 85° to 100°F for Eastman Kodak Ektachrome-X, Ektachrome Type B, and Ektachrome High Speed films using spiral reels. (Trade names and company names are included for the benefit of the reader and do not imply an endorsement or preferential treatment by the U.S. Department of Agriculture of the product listed.) The times, in minutes, that the films remain in the various solutions for the two processing temperatures are:

| Solutions | Minutes at 100°F | Minutes at 85°F |
|---|---|---|
| Prehardener | 2 | 3 |
| Neutralizer | ½ | 1 |
| First Developer | 2½ | 7 |
| First Stop | 1 | 2 |
| Wash | 1 | 4 |
| Color Developer | 3½ | 9 |
| Second Stop | 1 | 3 |
| Wash | 1 | 3 |
| Bleach | 1 | 5 |
| Fixer | 1 | 6 |
| Wash | 1 | 6 |
| Stabilizer | ½ | 1 |
| | 16 | 50 |

These adjustments in processing procedures have shortened darkroom time 34 minutes. Hence, a sizeable saving of time and money has resulted. However, certain cautions must be observed. Continuous agitation is required at the 100°F temperature, and rapid film transfer from one solution to the other is necessary for satisfactory photographic results. Also, it is advisable to increase air exchange in the darkroom to avoid possible toxic vapors.

If instructions are followed, the color balance is stable, and the emulsion is of high quality. Use the ASA speed indicated on the data sheet packaged with the film.

The modified processing described has been used since June 1, 1970, and no rolls have been ruined. Therefore, this modified processing should be helpful for color photography that is used in horticultural research.

## ACKNOWLEDGEMENT

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Figures should be unmounted. On a separate page, type the figure numbers (Fig. 1) and captions for each figure. On the back of each unmounted photograph or graph, use a soft-lead pencil to carefully write the figure number and the paper's title and author.

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ON THE COVER:

A typical Lower Rio Grande Valley scene depicted by Mrs. Marjorie Harrop, a local artist and USDA employee.