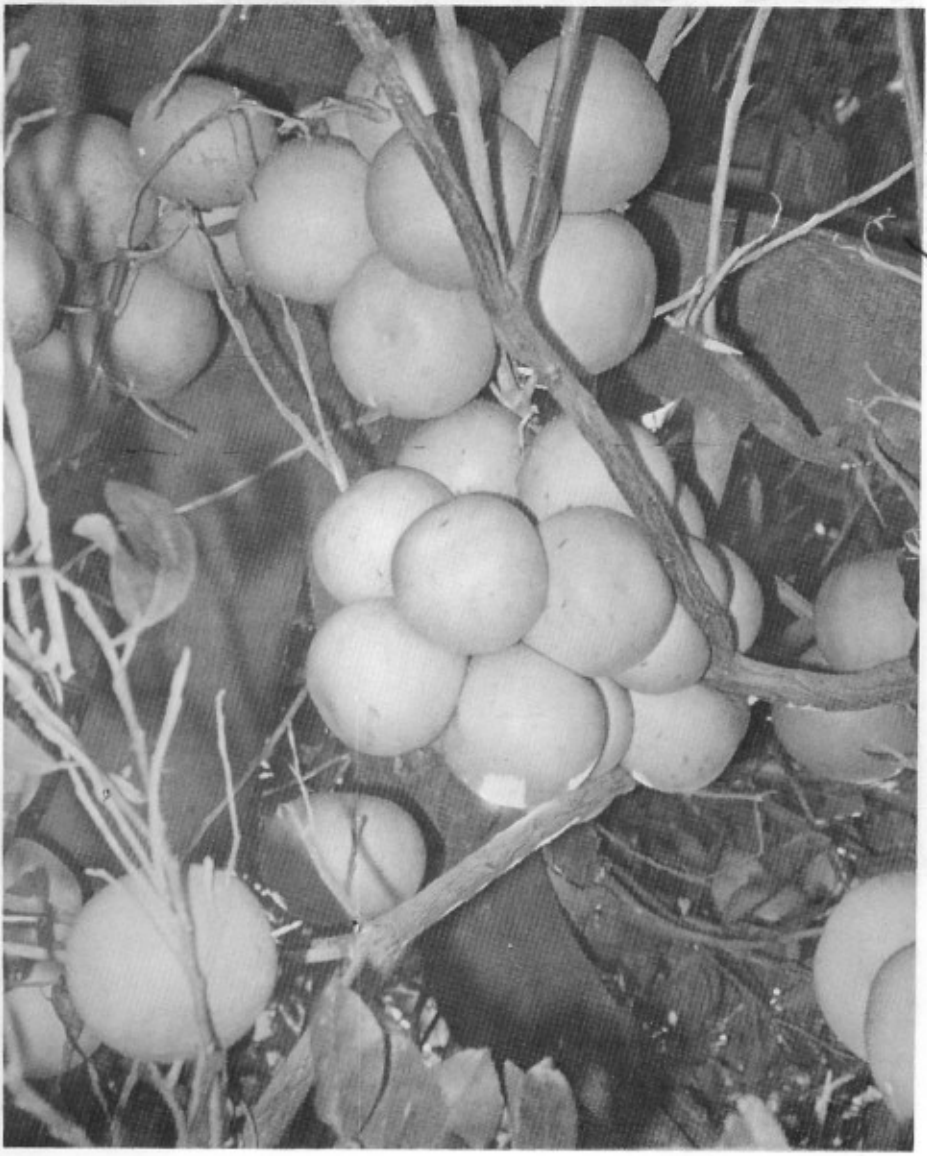

JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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Aims and Objectives of the Society

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

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

The Society sponsors an annual Institute featuring outstanding speakers from all parts of the world who present new developments in the field of horticulture. Panel discussions, social get-togethers, and a barbecue complete the all day program.

The *Journal of the Rio Grande Valley Horticultural Society* provides a continuing record of horticultural progress. Along with research reports, talks given at the Institute are published in the *Journal.*

Anyone interested in horticulture can become a member of the Society. The annual dues of $7.50 include a subscription to the *Journal.* Subscriptions by institutions and libraries are $10.00 a year. Applications for membership or subscriptions should be sent to the Secretary, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas 78596.

Call for Papers

Papers are requested for inclusion in Volume 40, 1987 of the Journal of the Rio Grande Valley Horticultural Society. Manuscripts of a scientific or practical nature pertaining to horticulture will be considered for publication. All papers, including written versions of presentations from the Annual Institute, will be subject to review. Separate guidelines for the preparation of research and non-research papers are printed in the back of this issue. The deadline for submission of papers for Volume 40, 1987 will be January 31, 1987. Manuscripts for publication in the Journal may be sent to:

Journal Editor
Rio Grande Valley Horticultural Society
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Weslaco, Texas 78596

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FORTIETH ANNUAL HORTICULTURAL INSTITUTE

Program of Paper Presentations, January 1986

Fruit Section

"The Threat of Citrus Canker" Dr. R. Michael Davis, Plant Pathologist, Texas A&I Citrus Center, Weslaco, Texas

"Peaches, Apples, Avocados, Nectarines; Alternative Fruit Crops for the Valley", Dr. Robert Rouse, Citrus and Specialty Fruits, Texas A&M Experiment Station, Weslaco, Texas

"Effectiveness of Malathion - Protein Bait Sprays for Mexican Fruitfly Control", Mr. Tim Holler, Entomologist USDA, A.P.H.I.S., P.P.Q. Mission Methods Development Center, Edinburg, Texas

"The Mexican Fruitfly Problem: Alternatives for Protecting Fresh Fruit Commodities", Dr. Leroy Williamson, Research Entomologist, Subtropical Crop Insects Research, Weslaco, Texas

"Pecans for the Valley", Dr. Richard Hensz, Director Texas A&I Citrus Center, Weslaco, Texas

Vegetable Section

"Texfresh: Focusing National Attention on Texas Vegetables" Mrs. Paula Fouchek, Texas Fresh Promotional Board, Harlingen, Texas

"Growing Vegetables for Direct Consumer Sales" Mr. Tom Longbrake, Texas A&M University, College Station

"Insect Growth Regulators and Plant Extracts to Control Vegetable Leaf Miners" Dr. Larry Chandler, Research Entomologist, USDA, Weslaco, Texas

"Trends in Texas Vegetable Production" Mr. Mike Kirby, General Manager, Valley Onions, McAllen, Texas

"Row Cover Techniques for Improving Earliness in Bell Peppers" Dr. Frank Dainello, Texas A&M Experiment Station, Uvalde, Texas

"New Pepper Harvester" Mr. John Posselius, Research Associate Texas A&M Experiment Station, Weslaco, Texas

Ornamental Section

"Landscaping with a Plan" Mr. Clark Curry, Registered Landscape Architect, Curry Landscape Service

"Ornamental Research at TAES Weslaco Will Benefit Nursery Growers", Dr. Yin Tung Wang, Horticulturist, Texas A&M Experiment Station, Weslaco, Texas

"Do's and Don'ts on Buying Plant Material" Mr. Carl Netz, General Manager, Tropical Gardens, Brownsville, Texas

Garden and Landscape Section

"Roses for the Valley" Mr. Morris Clint, Palm Garden Nursery, Brownsville, Texas

"Gardens for Small Spaces" Mr. Bryan Hutson, Stuart Place Nursery, Harlingen, Texas

"Palm & Cycads for the Rio Grande Valley" Mr. Glyn Whiddon, Stuart Place Nursery, Harlingen, Texas, and Mr. Morris Clint, Palm Garden Nursery Brownsville, Texas.

GUIDELINES FOR SELECTING THE RECIPIENT OF THE ARTHUR T. POTTS AWARD

1. The Arthur T. Potts award is to be given to an individual for outstanding contributions to the Horticultural Industry of the Lower Rio Grande Valley. The recipient may be from Industry, State or Federal agencies and need not reside in the Rio Grande Valley nor have been a member of the Society.
2. The members of the selection committee are to be appointed by the President no later than 1 July. The committee will consist of at least four members from the membership of the Rio Grande Valley Horticultural Society. At least one representative from some phase of production horticulture, ie., chemical sales, consultant, producer or supplier, must be a member of the committee. In addition, one member must be a carryover from the previous year to insure continuity within the committee.
3. The committee is to select a candidate for the award and to submit the candidate's name to the Board of Directors for approval by 15 October so that pictures and biographical sketch of the recipient can appear in the Journal of the Rio Grande Valley Horticultural Society the same year the award is presented. In the event the Board of Directors rejects the candidate, the selection committee must then select another candidate and submit this selection to the Board.
4. The committee is to solicit names of candidates for the award from the membership each year. The newsletter may serve as a satisfactory agent of solicitation by including in it a statement indicating that the committee is accepting nominations for the award from the membership.
5. The committee is to keep records of all meetings; these records to include a list of candidates considered for the award and this list passed on to the selection committee the following year. These candidates may then be reconsidered for the award. The Secretary of the Society is responsible for maintaining a file of these records.
6. The committee is responsible for providing a biographical sketch of the recipient, determining the appropriate wording for the plaque and having it ready in time for the Annual Institute.
7. The committee is responsible for purchasing the plaque for the following year in order to insure that a plaque is always available for engraving. The Secretary shall be responsible for storing the plaque.
8. The Arthur T. Potts Award shall be presented to the recipient at the Annual Institute by the President or his appointed representative.

GEORGE PLETCHER, JR.

1986 Recipient of the Arthur T. Potts Award

George Pletcher, Jr. began his nursery career at the age of 9 when his father established Pletcher's Wholesale Nursery at its present Harlingen location in 1922. Palms were the mainstay of the nursery, but the Pletchers also had a retail florist and nursery business as well as interests in cotton, citrus and gift fruit packing.

George majored in landscape art at Texas A&M University, from which he graduated with honors in 1936. He received the Master of Science in landscape from Ohio State University in 1937. He is a registered Texas Landscape Architect.

George and his wife Rachel became sole owners of Pletcher's in 1951 and they continued to operate the florist and both retail and wholesale nurseries until 1961 when they sold the florist and retail nursery operations to concentrate on the wholesale nursery.

Pletcher's is certainly among the oldest nurseries in the Valley and is currently among the largest, having some 300 acres of field stock and about 300,000 square feet of greenhouses.

Palms have been the mainstay of Pletcher's since its founding and George has donated over 30,000 palms to Valley communities, schools and churches. George also served the Valley community and the nursery industry during the 1950's by hosting a weekly radio program and writing a weekly newspaper column on gardening and landscaping. He has contributed both time and money to the development of research and extension programs in nursery production at the Weslaco Center and his experience and knowledge have been shared willingly at local, state and national meetings.

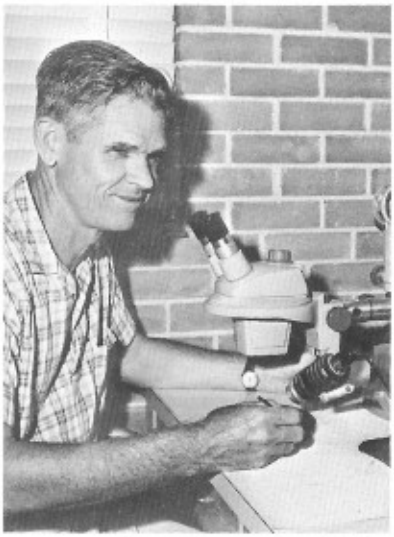
George served as President of both the Texas State Florist Association and the Texas Association of Nurserymen. He named the "Tropical Trail" in South Texas as part of the Texas Trails highway system. To support his conviction that today's youth are tomorrow's leaders, George has contributed over $12,000 to the Texas Association of Nurserymen—Texas A&M University scholarship fund for students majoring in ornamental horticulture.

George has received numerous honors during his career, most recent being the Texas Association of Nurserymen "Arp Award" in 1983 and the Valley Nursery Growers Association "Outstanding Grower" Award in 1985.

George gives much of the credit for his success to his wife, Rachel, for her personal support and her active participation in the family business. Moreover, he is proud that a daughter, Linda Broyles, a son-in-law, Larry Galbreath, and a grandson, Blake Broyles, are active participants in the nursery, thereby carrying Pletcher's Wholesale Nursery through 4 generations.

HERBERT A. DEAN

1987 Recipient of the Arthur T. Potts Award



Herbert A. Dean, born in Damon, Texas, soon moved with his family to McAllen in 1925. After graduating from McAllen High School in 1936, he studied 2 years at Edinburg Junior College (now Pan American University) then transferred to Texas A&M. He had completed his B.S. in Agriculture and had almost finished his Masters when World War II intervened. After 4 years in the Navy, Herb returned to A&M and completed his Master's work in 1947. After working a couple of years with the Extension Service out of College Station, he was transferred to A&M's research unit in Weslaco in 1950. The remainder of his professional career was spent as research entomologist at Weslaco except for about 13 months advanced study at the University of California, Riverside. He retired from A&M in 1983 and presently resides in Weslaco.

One of Herb's early projects was the elimination of Rhodes grass mealybug through the introduction of parasites, a forerunner and classical example of biological pest control. This expertise and philosophy was later transferred to citrus where his individual and team research efforts resulted in the successful control of citrus mealy bugs, purple scale and barnacle scale largely with natural predators or parasites. His contribution in developing the specifications for summer spray oil has provided the basis for the popular use of this material in citrus pest control. Herb's life long interest and emphasis on the role of beneficial insects in pest control marked him as one of the pioneers in biological pest control. In the late 60's Herb correctly identified the problem of leprosis or false spider mite damage on grapefruit as resulting from destruction of the mite's natural enemies through the use of certain organo-phosphate sprays. A record of his work and contributions to Valley and horticulture worldwide is well documented in the more than 50 scientific and popular publications Herb has authored or coauthored during his career. Recognition of his expertise came in 1970 when he organized the citrus program at the first working conference on integrated pest management in Nevada. The number and quality of his contributions to this society's journal have done much to enhance the prestige and value of our publication throughout the world.

Herb has been a member of the Entomological Society of America since 1940 and was a founding member (number 20) of the American Registry of Professional Entomologists, a nationwide organization which began with the Southwest Branch, of which Herb was a founding member.

In 1945 Herb married the former Betty Laughlin. The couple have two boys: Barry, who works with NASA in Houston and Allen, who is following in his dad's footsteps as cotton entomologist at Texas A&M University, College Station. Two granddaughters and a grandson complete the Dean family register.

In community affairs, Herb has contributed 20 years of service as member and elder in both the Weslaco and Donna First Christian Churches. An Eagle Scout himself, he served as scoutmaster of Troop 34, Weslaco, where both his boys also earned their Eagles. He was a member and officer of the Weslaco "Noon" Lion's Club. For over 25 years he has been witness to and actively involved in the work of the Rio Grande Valley chapter of the American Diabetes Association as board member and worker. Herb's almost all-consuming hobby of the discovery, preparation and handicrafting the woods of native and other Valley trees has delighted and astonished all who have shared in his hobby through conversation and his informative talks on this subject.

Journal Rio Grande Valley Horticultural Society, Vol. 39, 1986.

Influence of Mycorrhizal Fungi on Root Rots of Citrus

R.M. Davis, Associate Professor, H.S. Wilhite, Research Assistant,
Texas A&I University Citrus Center,
Weslaco, TX 78596,
and S. Hadi, Technician, Ministry of Agriculture, Amman, Jordan

ABSTRACT

Four species of mycorrhizal fungi, two levels of soil phosphorus, and two soil-borne pathogens of citrus, *Phytophthora parasitica* Dast. and *Thielaviopsis basicola,* (Berk. and Br.) Ferr. were evaluated for their effects and interactions on growth of sour orange seedlings. Growth of the seedlings was increased by all the mycorrhizal fungi but decreased by the pathogens. Although mycorrhizal seedlings offset the effects of the pathogens compared to the nonmycorrhizal seedlings due to a nutritional advantage, mycorrhizal fungi in general conferred no resistance to the seedlings. However, seedlings fertilized with phosphorus and infected by one of the mycorrhizal fungi, *Glomus intraradices,* were only slightly affected by *T. basicola.*

Several studies indicate that vesicular-arbuscular mycorrhizal fungi can increase tolerance of citrus plants to soil-borne diseases by absorbing phosphorus and certain other minerals that are unavailable to nonmycorrhizal plants (1-3). Apparently, mycorrhizal citrus is better able to offset the effects of the pathogens due to improved nutrition rather than by direct influence of the mycorrhizal fungus itself. If this theory is correct, then those mycorrhizal fungi which provide the greatest growth responses would confer the greatest degree of tolerance to soil-borne diseases. Recently, many mycorrhizal fungi were screened for excellent growth responses in citrus (4). In this study we determined the interaction between some of these highly efficient mycorrhizal fungi and two soil-borne pathogens, *Phytophthora parasitica* Dast. and *Thielaviopsis basicola* (Berk. and Br.) Ferr. We attempted to minimize the role of phosphorus nutrition in the interaction to evaluate the mycorrhizal fungi for possible resistance as well as tolerance conferred to the plants.

MATERIALS AND METHODS

Sour orange (*Citrus aurantium* L.) seeds were sown in wooden flats (20 x 40 x 12 cm deep) containing a sterilized sandy soil. The soil, which contained 1.6 μg P/g soil, was amended in one treatment with finely ground superphosphate [$Ca(H_2P0_4)_2 \cdot H_20$] at 100μg P/g soil and inculum of several mycorrhizal fungi: *Glomus intraradices* Schenck and Smith isolate DT102; *Gigaspora heterogama* (Nicol. and

Gerd.) Gerd. and Trappe isolate DT104; *Sclerocystis coremioides* Berk. and Broome isolate DT101; and *Glomus fasciculatum* (Thaxter) Gerd. and Trappe isolate 92. All but the latter, which was isolated from citrus in California, were isolated from citrus in Texas. Inoculum for each flat consisted of the contents from a 15 cm diameter pot culture of infected sudangrass (*Sorghum vulgare* Pers.) which contained hyphae, vesicles, and spores of each mycorrhizal fungus. The flat of nonmycorrhizal sour orange seedlings at each level of soil phosphorus received soil and roots of nonmycorrhizal sudangrass plants.

Five months later the seedlings were transplanted individually into 15 cm diameter pots containing sterilized sand amended as before with or without single superphosphate at 100μg P/g soil. At transplanting some of the pots also received inoculum of *Phytophthora parasitica* or *Thielaviopsis basicola* immediately before the seedlings were transplanted. There were ten replicates per treatment. Inoculum of *T. basicola* consisted of spores and mycelia produced by the method of Tsao and Van Gundy (9). Two hundred and fifty milliters of autoclaved V-8 broth in each of 20 2-liter flasks was inoculated with four 5 mm agar plugs of *T. basicola* cut from a 7-day-old culture grown on V-8 agar. After a 24 hr incubation period at 25° C, each flask was shaken and incubated horizontally for an additional 10 days. The cultures were then pooled, macerated in a blender, rinsed in sterile distilled water, and mixed into the soil. Each pot received 50 ml of inoculum.

The soil infested with *P. parasitica* received 50 chlamydospores of *P. parasitica* isolate S11 (originally from citrus in Texas). Chlamydospores were produced and collected in water by the method of Tsao (8). The percentage of chlamydospores which germinated after an incubation period of 24 hr at 24°C in a solution containing equal parts of 0.01 M glucose and 0.01 M asparagine was 88%.

At the time the seedlings were transplanted root samples were collected and stained with 0.05% trypan blue in lactophenol (7), placed on a grid of 1 mm^2 divisions, and examined for arbuscles, vesicles, spores, and hyphae of the mycorrhizal fungi in 100 or more 1 mm^2 sections of root tissue. The percentages of root tissue with structures of the mycorrhizal fungi ranged from 34 to 52%. There were no significant differences in infected roots between the various species of fungi or between soil phosphorus levels.

The seedlings were grown in a glasshouse at 22 to 32° C with a relative humidity of 66-100% and watered every other day with a Hoagland's solution (5) lacking phosphorus. After 15 weeks the seedlings were lifted from the soil and their dry weights were recorded. Samples of roots were stained as previously described to estimate percentages of root tissue infected with the mycorrhizal fungi. Phosphorus content in leaves was determined by the molybdate-$SnCl_2$ method (6).

RESULTS AND DISCUSSION

Growth of the sour orange seedlings was increased by both the addition of phosphorus to the soil and by infection with the mycorrhizal fungi (Table 1). There were no significant differences in growth responses between the species of mycorrhizal fungi.

There was a significant interaction between the mycorrhizal fungi, phosphorus levels, and pathogens. Although *P. parasitica* and *T. basicola* significantly reduced the weight of all the nonmycorrhizal and mycorrhizal seedlings, those seedlings grown in soil amended with 100μg P/g and infected with the fungus *G. intraradices*

were only slightly affected by *T. basicola* (Table 2). Otherwise, the mycorrhizal fungi did not influence the relative growth reduction of seedlings inoculated with the pathogens. In soil not amended with phosphorus, *P. parasitica* and *T. basicola* reduced seedling growth by 16% and 39%, respectively.

Table 1. Influence of soil phosphorus and mycorrhizal fungi on total dry weights of sour orange seedlings.

Treatment	Total dry wt (g)
Soil P	
None (control)	1.84
100μg P/g soil	3.28*
Mycorrhizal infection	
None (control)	0.81
Infected	2.99*

*Significantly different from the control mean at the 1% level of probability.

Table 2. Reductions in the total dry weights of mycorrhizal sour orange seedlings inoculated with *Phythophthora parasitica* or *thielaviopsis basicola.*

	100 μg P/g soil		
	wt of	% reduction of wt by:	
Mycorrhizal fungus	noninoculated seedlings (g)	*P. parasitica*	*T. basicola*
None	1.42	12	26
Glomus fasciculatum	4.82	11	23
G. intraradices	4.21	18	6*
Gigaspora heterogama	3.69	17	31
Sclerocystis coremioides	4.38	10	21
		NS	

*Significantly different from the means in this column at the 1% level of probability.
NS = not significant.

Amending the phosphorus-deficient sand with 100μg P/g soil did not significantly reduce the intensity of infection by the mycorrhizal fungi (data not presented). There were no significant interactions between the mycorrhizal fungi, phosphorus levels, and pathogens. Inoculation with *T. basicola,* but not *P. parasitica,* reduced the amount of infection by the mycorrhizal fungi across both soil phosphorus levels. There were no significant differences between the intensity of infection of the various mycorrhizal fungi. Phosphorus concentrations in the plants were increased by the mycorrhizal fungi and phosphorus fertilizer, but there were no significant interactions with the pathogens (data not presented).

In general, these mycorrhizal fungi had no effect on root rot caused by either *P. parasitica* or *T. basicola.* Despite the larger size of the mycorrhizal plants compared to the nonmycorrhizal plants, the relative reduction in growth by the pathogens was similar. Thus, there was little indication of increased resistance or susceptibility conferred to the seedlings by mycorrhizae other than the ability of the mycorrhizal seedlings to offset the effects of the pathogen by a nutritional advantage. However, one fungus, *G. intraradices,* may have provided some degree of resistance against *T. basicola* since growth of the seedlings infected with this mycorrhizal fungus was only slightly reduced by *T. basicola.* The mechanism for this protection is unknown, but the phosphorus level in the leaves of the seedlings and the intensity of mycorrhizal infection were not unique to the fungus.

Whether *G. intraradices* can provide a significant amount of protection for citrus seedlings against *T. basicola* in the field is unknown, but this fungus is a good choice for use in sterilized soils or soilless potting mixes. The growth responses by this fungus were equal to those caused by *G. fasciculatum* 92, which causes excellent growth responses in citrus (4).

These results confirm earlier studies (1-3) where mycorrhizal fungi in citrus did not generally confer resistance against citrus diseases. Although reductions in disease incidence has been demonstrated in some plant-pathogen systems, actual resistance conferred to plants by mycorrhizal fungi, other than the nutritional advantage by the mycorrhizal association, may be unusual. Instead, it appears that exploiting those mycorrhizal fungi which can best cause growth increases can offer the best means for reducing plant loss to soil-borne diseases.

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Effect of Film Wrapping on Postharvest Decay Incidence of Texas Grapefruit

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ABSTRACT

Wrapping individual fruit in 0.05 mm thick, heat-shrinkable, low-density polyethylene sheets had no effect on the incidence of postharvest decay of 'Star Ruby' and 'Ruby Red' grapefruit through 86 days of storage. However, the incidence of decay of refrigerated (14 °C) fruit was significantly reduced in film-wrapped fruit between the 86th and 135th day of storage. Wrapped fruit were stored under refrigeration for 261 days with 25% loss to decay. Postharvest treatment with benomyl and sodium-o-phenyl phenate or 2,4-D decreased decay incidence at the same rate whether or not fruit were wrapped. 'Star Ruby' fruit had a higher incidence of postharvest decay than did 'Ruby Red' fruit.

Wrapping individual grapefruit in heat-shrinkable polyethylene film has been tested as an alternative to waxing for the reduction of transpirational water loss (3,4,7,10,12). Although decay of grapefruit has been reduced by polyethylene films over a period of 40 days, the effects of these films on decay incidence during long-term storage is less well known (1,5,7,9). Conceivably, the shelf life of fresh citrus can be significantly lengthened by film wraps; thus, information is needed to determine the effectiveness of postharvest treatments to control decay of wrapped fruit stored for many months. A five-way factorial experiment was conducted to determine how film wraps interact with a fungicide and growth regulator at 2 temperatures on 2 grapefruit cultivars during long term storage.

MATERIALS AND METHODS

Test fruit were harvested on February 7 and 8, 1983, from 2 grapefruit varieties (*Citrus paradisi* Macf. cvs. Star Ruby and Ruby Red) grown on sour orange (*C. aurantium* L.) rootstock in experimental orchards at the Texas A&I University Citrus Center, Weslaco. Only fruit of USDA Standard No. 1 quality (few or no blemishes) were used. Fruit were hand-washed under tap water and air dried in the laboratory.

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The factorial experiment included: the 2 cultivars; fruit wrapped or not wrapped with a heat-shrinkable film (100 gauge) applied with a Cryovac Magna-lok Edgeseal Machine (Cryovac Division, W.R. Grace and Co.) and shrunk in a Cryovac shrink tunnel; fruit submerged for 1 min. in water or a fungicide bath containing 2% a.i. sodium-o-phenyl phenate (SOPP) and 60 mg/1 a.i. benomyl at pH 11.5; fruit submerged for 1 min. in water or in a solution containing 500 ppm of 2,4-dichlorophenoxy-acetic acid (2,4-D); and fruit stored at 14 or 24 °C.

Each treatment consisted of 3 standard commercial 40-pound boxes of 25 randomly selected fruit. Boxes were stored in a completely randomized design in either a walk-in refrigerator or temperature-controlled storage room. Air was circulated in both locations with fans. The relative humidity was about 88% in the cold room and 75% in the room kept at 24 °C. The percentage and type of decay in each box were recorded every 2 weeks. Decayed fruit were discarded each time data were recorded. The percentages of decay were subjected to analysis of variance after arcsin transformation. The experiment was terminated after 261 days.

RESULTS AND DISCUSSION

Significance levels of main effects and some interactions are summarized in Table 1. Because significant 3-, 4-, and 5- way interactions were rare, only main effects and 2-way interactions are presented. Most of the results can be explained by main effects alone. Unwrapped fruit stored at 24 °C were discarded after 86 days due to desiccation and deterioration, whereas unwrapped refrigerated fruit were discarded after 135 days. Wrapped fruit stored at 24 °C were discarded after 233 days and wrapped refrigerated fruit were discarded after 261 days.

There were no significant differences between the percentages of postharvest decay of wrapped and unwrapped fruit stored at 24 °C. However, the incidence of decay in refrigerated unwrapped fruit was significantly greater than that in refrigerated wrapped fruit between the 86th and 135th day of storage (Fig. 1). Thereafter, decay of wrapped fruit increased relatively rapidly.

'Star Ruby' grapefruit was more susceptible to decay than 'Ruby Red' grapefruit (Fig. 2). Although the difference in the incidence of decay did not appear until after 135 days of storage, the differences increased during the course of the experiment.

Refrigeration and treatment with fungicides or 2,4-D generally reduced the incidence of decay on all sampling dates (Table 2). The growth regulator, 2,4-D reduced the incidence of stem-end rot by approximately 35%, but had little or no effect on green or blue mold (data not presented). There were no interactions between wrapping and 2,4-D or wrapping and the fungicide treatment (Table 1).

A 40-day experiment in Florida showed the healing process was enhanced in grapefruit wrapped in polyethylene film and incidence of postharvest decay was reduced (7). Other studies lasting up to 63 days have found inconsistent effects of shrink-wrap films on the incidence of decay in grapefruit (4). It might be expected that decay incidence would be higher in wrapped fruit because of the high relative humidities surrounding the fruit. Indeed, Grierson and Wardowski (8) reported higher decay incidences from fruit loosely wrapped in low-density polyethylene bags and attributed this increase to the water condensation inside the bag. However, insulation against secondary, contact infections and enhanced lignification in

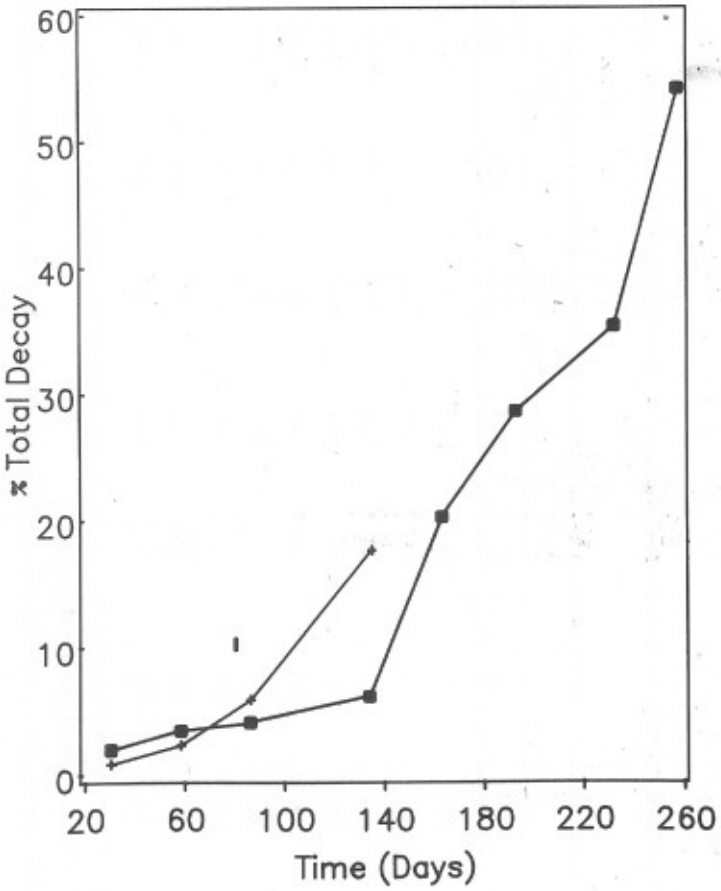

Fig. 1. Effect of low-density polyethylene film on the incidence of postharvest decay of refrigerated (14 °C) Texas grapefruit. (+) = unwrapped fruit, (■) = wrapped fruit. Bar represents 1 SE.

Table 1. Significance of some mean separations according to analysis of variance of the percentages of postharvest decay in a 5-way factorial experiment.

	Days post-harvest							
Factor	30	58	86	135	163	193	233	261
Wrap vs. no wrap, 24 °C	NS	NS	NS	--	--	--	--	--
Wrap vs. no wrap, 14 °C	NS	NS	NS	***	--	--	--	--
Star Ruby vs. Ruby Red	NS	NS	NS	NS	**	***	***	***
14 °C vs. 24 °C	NS	NS	***	***	***	***	***	--
Fungicide vs. no fungicide	**	***	***	***	NS	NS	NS	NS
2,4-D vs. no 2,4-D	NS	NS	*	***	***	***	***	NS
Wrap X cultivar	NS	NS	NS	NS	NS	NS	NS	NS
Wrap X fungicide	NS	NS	NS	NS	NS	NS	NS	NS
Wrap X 2,4-D	NS	NS	NS	NS	NS	NS	NS	NS

* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$; -- = comparison not made.

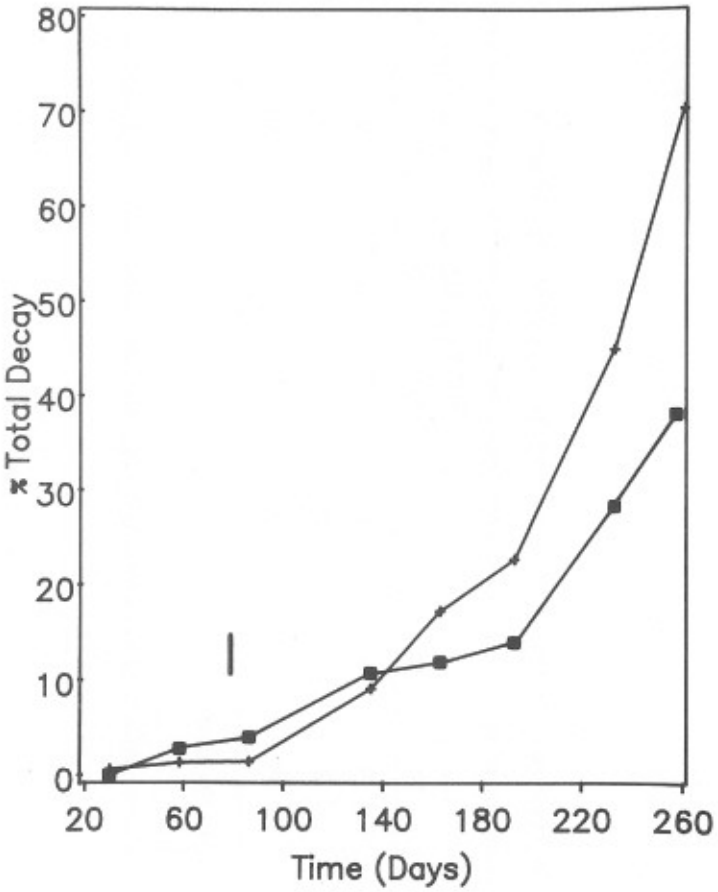

Fig. 2. Incidence of postharvest decay in 'Star Ruby' (+) and 'Ruby Red' (■) grapefruit. Bar represents 1 SE.

Table 2. Percentages of reductions in incidence of postharvest decay of grapefruit by cold storage, fungicide, or 2,4-D treatments.

	Days post-harvest							
Treatment	30	58	86	135	163	193	233	2 6 1
Refrigeration at 14 °C	0	0	8	7	5	8	7	--[z]
Fungicide[y]	2	3	5	5	0	0	0	0
2,4-D	0	0	3	8	7	6	11	0

[z] Fruit not refrigerated was discarded after 233 days.

[y] Fungicide treatment was beromyl + SOPP.

wrapped fruit which promotes the healing process have been attributed to polyethylene films (7).

Shrink-wrap film increased the storage life of the fruit in this study, especially when fruit was stored at 14 °C. These results are similar to those of Ben-Yehoshua et al. (4), who found that the wrap had a greater impact on storage-life than did storage temperatures, at least under experimental conditions.

Under long-term storage conditions, 'Star Ruby' grapefruit decayed to a greater extent than did 'Ruby Red' grapefruit. Although differences in the management of these two grapefruit cultivars have been found (6,11), this is the first report on differences in susceptibility to postharvest pathogens between the cultivars.

The use of polyethylene film wraps shows promise in long-term, postharvest storage of Texas grapefruit. The ability to store fruit for long periods is a prerequisite if grapefruit is to be available year-round (2). However, restrictions to the length of storage exist since the grapefruit stored for 261 days in this experiment developed a poor flavor. Changes in fruit physiology due to wrapping is an important limiting factor to their use. Postharvest decay is less a limiting factor in the use of film wraps since wrapping did not alter the effectiveness of standard packinghouse practices such as cold storage and the use of chemicals to reduce decay. In fact, wrapping reduced the incidence of decay in one storage interval under the conditions of this experiment. Further testing under conditions that exactly duplicate standard postharvest handling of grapefruit is needed to accurately define the feasibility of long-term storage of wrapped fruit.

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Juice Quality of Stored Polyethylene Seal-Packed Grapefruit

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ABSTRACT

The effects of individually sealing grapefruit with polyethylene (PE) film on the quality of the fruit and juice were evaluated on 'Ruby Red', 'Henderson', and 'Star Ruby' red-fleshed grapefruit (citrus, paradisi, macf.) cultivars. Sealed fruit stored for 18 weeks at 20°C and 85% relative humidity had lower quality juice values for °Brix, percent acidity, ascorbic acid, percent pulp, lycopene and naringin than juice from nonsealed fruit. Juice quality values for both PE sealed and nonsealed fruit were well within acceptable industry standards for quality. A taste panel did not detect flavor differences between the juice from sealed and nonsealed fruit throughout 16 weeks of storage. More external damage from stem-end rot and more internal decay caused by *Alternari citri*, Ellis and Pierce, was found for sealed than for nonsealed fruit. Sealed fruit kept its fresh and firm appearance during the sixteen week storage period and neither shrunk or deformed compared with nonsealed fruit that did shrink and deform. Nonsealed and sealed fruit lost moisture at the rate of 2.8 and 0.16 grams per week, respectively. These findings are indicative of the potential that the PE film wrapping method has for long term storage of grapefruit and the keeping quality of its juice.

INTRODUCTION

A packaging technique for citrus that individually seal-packages the harvested fruit with a high density polyethylene (HDPE) film to extend the shelf-life (4) and which has the potential to provide similar benefits to other fruits and vegetables has stimulated the interest of the packing industry (22) and food scientists. The technique for citrus involves shrinking the film to a tight bound fit around the fruit by passing the fruit through an oven at 190°C. The fruit can then be stored at desired temperatures in open bins or cold rooms. The film sealing insures the reduction of moisture loss by the fruit (1, 7) which in turn delays the normal deterioration process (5, 20, 3). Other beneficial uses of this technique include the sealing of 'Shamouti' oranges, grapefruit (4), and lemon fruit (6) after treatment for degreening with ethylene releasing agents. Wrapping grapefruit with HDPE film also accelerates wound healing caused when mechanically harvesting grapefruit (13). The use of growth regulators, to delay rind senescence, in combination with HDPE film-sealing and controlled storage was reported to be a promising method for supplying late citrus markets (12). Another beneficial effect of seal-packaging citrus includes the containment of decayed fruit to the single sealed fruit (22). However, the HDPE film does not effectively protect citrus fruit from the internal decay caused by *Alternaria citri* (4).

The HDPE film-sealing and storage of citrus for periods up to six months with minimal detrimental effects on the external quality led us to investigate the effects of combining PE seal-packing and storage at controlled temperature and relative humidity on the internal quality of the grapefruit and its juice from different red-fleshed cultivars.

MATERIALS AND METHODS

Fruit of 'Ruby Red', 'Henderson', and 'Star Ruby' were harvested December 19, 1983 from each of 8 trees; 'Ruby Red' fruit from Rio Farms, Monte Alto, Texas; 'Henderson' fruit from a privately owned orchard west of Edinburg, TX; and 'Star Ruby' grapefruit from the Texas A&I Citrus Center at Weslaco, TX. All trees were approximately 9-10 years of age.

The fruit were washed on a set of brush rolls. Fruit were then dipped in a 1200 ppm benomyl solution for 30 seconds and allowed to air dry. An equal number of fruit from each cultivar were then separated for film wrapping. Hand operated polyethylene film sealing equipment was furnished by Crest Fruit Co. of Alamo, TX. Polyethylene film of 60 mil thickness was used for wrapping. To shrink the film the fruit were exposed to an oven temperature of 190 °C (350 °F) for ten seconds. One hundred eight sealed and unsealed fruit from each cultivar were boxed in standard citrus cartons and stored in environmentally controlled chambers at 20 °C and 85% relative humidity for the duration of the investigation. At 2 week intervals through 18 weeks, five fruit, both sealed and nonsealed, were removed and processed for analysis. The fruit were also inspected for external and internal decay.

Juice of film sealed and nonsealed fruit from each cultivar was extracted with a Sunkist hand reamer. The juice from a five fruit sample of each cultivar was stored frozen in polyethylene bottles.

Juice flavor was evaluated by a taste panel of 10 laboratory personnel. Members scored the freshly extracted juices on a 9-point hedonic scale where 9 was extremely liked and 1 was extremely disliked. Samples were served at room temperature.

A subsample of 10 sealed and 10 nonsealed fruit from each cultivar was set aside at the time of wrapping. These fruit were labeled and put in storage at the conditions previously mentioned. At weekly intervals the fruit were weighed and returned to storage.

Fruit, both sealed and nonsealed, were visually inspected for shrinkage, deformation, appearance, pathogens, and loss of firmness each time the fruit was removed from storage and weighed.

Juice from each cultivar was analyzed for degrees Brix, percent acid, Brix/Acid ratio, pulp (suspended solids), and pH by standard industry procedures (19). Recoverable oil was carried out by the official AOAC procedure (2), naringin was determined by the Davis test (10), and vitamin C by the colorimetric procedure of Nelson and Sommers (18). Juice color was determined on a Gardner Model XL-10 Color Difference Meter using an LR-1 standard. Carotene and lycopene were assayed by the procedure of Lime et al. (14) with method B.

The sugars in the stored juices were separated by a Hewlett-Packard Model 10848B high performance liquid chromatograph on 230 cm x 7.8 mm BioRad HPX-87 Ca^{++} column and detected by differential refractometry. An HP model

79850B LC terminal/integrator attached to the HPLC was used to quantify each sugar peak.

The furfural content of the juices was determined by the colorimetric method of Dinsmore and Nagy (11).

RESULTS AND DISCUSSION

The effects of individually sealing grapefruit with polyethylene (PE) film and storing at 20°C and 85% relative humidity on the juice quality of each cultivar are shown in Table 1. Significant differences were observed between the percent acid of the juice from sealed and nonsealed grapefruit of two cultivars. The percent acid was highest in the nonsealed than in the sealed fruit from all three cultivars. Juice from the 'Henderson' nonsealed fruit had a higher ascorbic acid content than juice from sealed fruit. Juice from the 'Ruby Red' and 'Star Ruby' fruit was not so affected. The higher percent acid and ascorbic acid values obtained for nonsealed fruit may be due to a concentration effect as greater moisture loss occurred in the nonsealed fruit. The Brix/acid ratio was highest in juice from sealed fruit.

Film sealing also affected the Rd reading (reflectance) of the juice from sealed 'Star Ruby' fruit compared to unsealed fruit juice. A completely absorbing specimen would have an Rd value of zero, and a perfect diffusing white would have a value of 100. Redness (A) and yellowness (B) readings of the juice were not affected by PE film sealing of the fruit. Lycopene differences between the juice of the three cultivars were observed as previously reported (8, 9). The PE film sealing of grapefruit had no significant effects on other juice quality values measured. Juice from all three cultivars stored sealed and nonsealed had quality values well within acceptable standard grades throughout the experiment.

The taste panel did not detect flavor differences between the juice from PE sealed and unsealed grapefruit from 'Ruby Red', 'Henderson', and 'Star Ruby' cultivars (Table 2).

Published reports (4) indicate that percent decay of PE sealed citrus fruit depends on the fruit type, specific pathogen, and storage time. There were more PE film sealed fruit exhibiting external and internal decay than nonsealed fruit (Table 3). Chi square analysis of this data using Yates correction (15) for continuity indicates a significant increase in decay incidence in sealed than in nonsealed fruit. Externally more stem-end rot was observed in sealed fruit and more internal rot was caused by *Alternari citri*. Ben Yehoshua (4) attributed PE film enhancement of stem-end rot to two factors; the temperature increase of the fruit by seal-packaging and the better development of the pathogenic fungi in the water saturated micro atmosphere. Appearance and firmness were also affected by the PE film-packaging (Table 4). Sealed fruit kept their fresh appearance and firmness throughout storage and no shrinkage or deformation was observed. In contrast, nonsealed fruit showed signs of shrinkage, deformation, loss of firmness, and a soiled appearance within four weeks (not shown) of storage. This deterioration proceeded with increased storage time. As expected, there was a significant reduction in weight loss between sealed and nonsealed fruit from all cultivars at twelve weeks of storage. The PE sealed fruit lost 0.8 to 1.6% of original weight and nonsealed fruit lost 10.3 to 29.6% of original weight. A comparison of the mean weight losses for the ten sealed and nonsealed fruit revealed that the 'Henderson' fruit had weight losses significantly less ($p = .05$) than 'Ruby Red' or 'Star Ruby' fruit (Table 5). The

Table 1. Juice quality values for PE film sealed and nonsealed grapefruit.[z]

	Ruby Red		Henderson		Star Ruby	
	Sealed	Nonsealed	Sealed	Nonsealed	Sealed	Nonsealed
° Brix	9.30 a	9.50 a	9.80 a	10.10 a	10.60 a	11.00 a
% Acidity	1.26 b	1.33 a	1.25 a	1.31 a	1.24 b	1.34 a
% Pulp	15.10 a	16.00 a	16.40 a	16.60 a	17.40 a	17.90 a
Ascorbic Acid	29.30 a	31.50 a	30.86 b	34.50 a	23.10 a	25.10 a
Lycopene	0.07 a	0.07 a	0.35 a	0.38 a	1.25 a	1.40 a
Naringin	107.11 a	112.56 a	125.00 a	126.44 a	121.44 a	138.44 a
Brix/Acid	8.21 a	7.92 a	8.71 a	8.32 a	9.50 a	9.15 a
% Juice Yield	51.10 a	49.90 a	52.30 a	51.90 a	51.80 a	51.50 a
pH	3.22 a	3.17 a	3.26 a	3.19 a	3.25 a	3.25 a
% Sucrose	2.71 a	2.97 a	2.88 a	2.91 a	3.79 a	3.84 a
% Glucose	1.84 a	2.09 a	2.05 a	2.19 a	2.28 a	2.11 a
% Fructose	2.45 a	2.59 a	2.72 a	2.74 a	2.64 a	2.96 a
Rd	15.42 a	15.86 a	12.19 a	12.23 a	8.04 a	7.73 b
A	1.51 a	1.70 a	9.00 a	9.67 a	19.84 a	19.69 a
B	13.35 a	13.63 a	13.56 a	13.82 a	13.00 a	12.61 a

[z]Each value represents the mean of nine measurements during 18 weeks of storage. Means in a row with different letters are significantly different according to Duncan's Multiple Range Test, $p = 0.05$. Ascorbic acid, sucrose, glucose and fructose values in *mg*/100 ml. Lycopene values in *mg*/100 *g*. Naringin in ppm.

Table 2. Taste test scores[z] for juice from PE sealed and nonsealed grapefruit fruit after 16 weeks of storage.

Storage Time (Weeks)	Ruby Red		Henderson		Star Ruby	
	Sealed	Nonsealed	Sealed	Nonsealed	Sealed	Nonsealed
2	7.7	8.2	6.9	6.9	6.9	6.7
4	7.2	7.1	6.9	6.8	7.2	7.1
6	7.6	7.6	7.9	8.1	8.1	7.9
8	7.9	7.9	7.2	8.0	7.7	7.7
10	7.3	7.2	7.6	8.8	6.9	7.3
12	6.8	7.0	6.9	7.9	7.2	7.3
14	6.3	7.0	7.4	7.7	7.1	7.1
16	6.1	6.9	7.5	7.4	5.1	7.2
Mean	7.11	7.36	7.28	7.70	7.02	7.28
Std Dev.	0.657	0.480	0.375	0.659	0.879	0.372
t-Test	-0.87 NS		-1.54 NS		-0.78 NS	

[z]Each score represents the mean of ten taste test panelists. Scores are based on a 9-point Hedonic scale where 9 is extremely liked and 1 is extremely disliked.

Table 3. Percent of fruit with external and internal decay at 18 weeks of storage.[z]

Cultivar	Treatment	External Decay Percent	Internal Decay Percent
Ruby Red	sealed	7.4	2.8
Ruby Red	nonsealed	9.3	2.8
Henderson	sealed	10.2	7.4
Henderson	nonsealed	6.5	0.9
Star Ruby	sealed	17.6	10.2
Star Ruby	nonsealed	3.7	0.9

[z]Percent is figured on 108 fruit, sealed and nonsealed, from each cultivar. Chi square analysis ($x^2 = 15.5$, df = 1, $P > 0.001$) of the pooled data indicates a significant relation of decay incidence between sealed and nonsealed fruit.

'Henderson' fruit retained the most moisture at the same storage conditions than did the other two fruit cultivars. The weight loss by nonsealed fruit is likely the result of moisture loss from the peel rather than the flesh since very little section drying was observed when the fruit was sliced. Although it has been demonstrated (3) that diffusion of oxygen and carbon dioxide is reduced by the PE film packaging, fruit respiration is not adversely affected and the beneficial effect of seal-packaging citrus fruit is primarily due to a reduction in moisture loss. The rate of weight loss by the sealed and nonsealed fruit on storage can be determined from the regression equations on Table 6.

In studies on single strength orange (16) and grapefruit juice (17) furfural was found to be related to storage treatment and flavor change. It has also been observed that furfural content increases with increasing storage time (21). Therefore, furfural content in the juice of sealed and nonsealed grapefruit were determined. Results, not shown, indicated that at the 10th month of storage only the juice from nonsealed Star Ruby grapefruit developed furfural. This furfural content ranged from an initial 73.53 to a final 264.71 ppb at 18 weeks of storage.

CONCLUSION

Results indicate that PE film wrapping of grapefruit cultivars grown in the Lower Rio Grande Valley of Texas, does not adversely affect the quality of the juice when fruit is stored at 20 °C and relative humidity of 85% the first 14 weeks after harvest. However, PE film sealing does not protect the fruit from stem-end rot or internal rot caused by *Alternari citri*. PE film sealed fruit keep their fresh and firm appearance and exhibit no indication of shrinkage or deformation. A taste test panel did not detect significant flavor differences between the juice of sealed and nonsealed fruit at 16 weeks of storage.

Table 4. External quality scores and observations for PE film sealed and nonsealed grapefruit.[z]

	Ruby Red		Henderson		Star Ruby	
	Sealed	Nonsealed	Sealed	Nonsealed	Sealed	Nonsealed
	2 Weeks of Storage					
Shrinkage	N	N	N	N	N	N
Deformation	N	N	N	N	N	N
Appearance	9	9	9	9	9	9
Firmness	9	8	9	8	9	8
	8 Weeks of Storage					
Shrinkage	N	SL	N	SL	N	SL
Deformation	N	SL	N	SL	N	SL
Appearance	8	6	8	6	8	6
Firmness	9	6	9	6	9	6
	16 Weeks of Storage					
Shrinkage	N	FA	N	FA	N	FA
Deformation	N	FA	N	FA	N	FA
Appearance	8	2	8	2	8	2
Firmness	9	3	9	3	9	3

[z] scores represent decreased quality. N = none, SL = slight, and FA = fair amount.

Table 5. Mean weight losses of sealed and nonsealed grapefruit cultivars at 12 weeks of storage.

	Mean wt Loss (*g*)	
Cultivar	Sealed	Nonsealed
Star Ruby	5.50[z] a	74.07 a
Ruby Red	4.69 a	71.18 a
Henderson	3.43 b	56.92 b

[z]Means in the same column followed by the same letter are not significantly different at the 5% level.

Table 6. Regression equations of weight loss rate for sealed and nonsealed grapefruit cultivars.

	Ruby Red	Henderson	Star Ruby
Sealed	y = -0.378X + 385.9	y = -0.257X + 358.7	y = -0.292X + 470.1
Nonsealed	y = -6.257X + 388.5	y = -4.722X + 386.0	y = -5.612X + 520.2

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Mexican Fruit Fly

Anastrepha ludens (Loew). (Diptera; Tephritidae)
A Selected Bibliography
1888-1986

Timothy C. Holler[1] and Carrol O. Calkins[2]

The Mexican fruit fly, *Anastrepha ludens* (Loew), was first detected from infested citrus in Texas in 1927 (unpublished reports). Adults have been trapped annually in the citrus producing area of the Lower Rio Grande Valley ever since. Entomologists from the U.S. Department of Agriculture (USDA), were sent to Mexico to evaluate the potential importance of this pest when it was suspected that it was spreading from its place of origin. Methods were developed for controlling the fly and for treating potentially infested fruit to destroy any stages of the fruit fly. This allowed the product to pass quarantine and to be sold in uninfested areas. Much of the developmental work was conducted at a USDA-Agricultural Research Service (ARS) laboratory in Mexico City in cooperation with the Mexican Defensa Agricola (now Sanidad Vegetal), over a 40-year period. A review of research conducted on the Mexican fruit fly (and citrus blackfly) at the laboratory in Mexico was published by J.G. Shaw et al. (1970) and is included herein. Following the closing of the laboratory, less emphasis was placed on Mexican fruit fly research. However, limited studies continued in Mexico, Brownsville and Weslaco, Texas and Beltsville, Maryland.

A renewed interest in Mexican fruit fly occurred when the Environmental Protection Agency (EPA) announced that a ban on the use of ethylene dibromide as a regulatory treatment of citrus would go into effect after September 1, 1984. Consequently, additional research was started to identify alternatives to ethylene dibromide fumigations. Much of this research addressed the need for commodity treatment. Likewise, management systems including the use of bait-sprays and sterile insect techniques were re-evaluated in both Texas and the Republic of Mexico. A new rearing facility was constructed in Texas to mass produce sterile Mexican fruit fly for release in the Rio Grande Valley and funding was approved by California to maintain a fly culture in Texas for production of sterile flies for its use as required. Procedures for mass rearing of the fruit fly are also being reviewed and modified as necessary.

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This bibliography was compiled to summarize pertinent research literature on *A. ludens* for use by students, scientists, growers, pest control specialists, administrators, etc. The standard format used for the literature citations followed that recommend by the Entomological Society of America as illustrated in the Bulletin. The review by Shaw provided the greater portion of the references cited, although not all of the papers he lists are included here. Bibliographic sources also included computer assisted literature reviews, i.e. Agricola; Biological Abstracts; Chemistry Abstracts; Review of Applied Entomology-Series A; Zoologial Records; BIOSIS Previews; and Commonwealth Agricultural Bureaux File. Other references cited were extracted from trade magazines; texts; bulletins; circulars; commission proceedings, etc. A limited number of references were obtained from in-house sources, references which were not submitted to indexing services for data base inclusion, i.e. fruit fly identification keys, research publications, meeting memoirs. Generally, these references were provided by government and university, program and research personnel in Mexico. The literature search for this bibliography was completed in October 1986.

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The Mexican fruit fly, *Anastrepha ludens* (Loew), is believed to have originated in northeastern Mexico. Long association with native host plants found in this region, particularly yellow chapote, *Sargentia greggii* S. Wats., preceded its spread into introduced cultivars such as citrus and mango (Baker et al. 1944). Presently its range extends southward from the Lower Rio Grande Valley of Texas throughout Mexico, Central America and into northern South America. Since 1954, flies have been periodically captured on both sides of the California-Mexico border where a continuous detection and eradication program is enforced. Although first trapped and identified in the Rio Grande Valley in 1903, a hard freeze in 1904 appeared to have eliminated the fly (Ryall and Pentzer, 1974). The first attempt at eradication was begun in 1927 following discovery of infested citrus fruit. Eradication efforts were unsuccessful and suggested that flies were migrating to Texas from their native habitat. The governments of Mexico and the United States promptly initiated an informal cooperative research agreement. The 40 year operation (1928 to 1968) of the USDA/ARS Mexican Fruit Fly Laboratory in Mexico City was instrumental in elucidating the economic importance of native fruit flies, control methodology and commodity treatment measures (see Shaw et al. 1970).

Gravid female tephritid flies characteristically search for ripening fruit in which to deposit eggs. The ovipositor of *A. ludens* is a sharp, blade-like structure used to pierce the peel of host fruit and through which eggs are deposited. Fruit are subsequently destroyed by feeding larvae as they burrow throughout the flesh.

Time required for larval maturation is strongly influenced by host type as well as climate. In preferred hosts, development in fruits may range from 9 to 35 days under favorable temperature. Mature larvae emerge from the fruit and burrow into the soil to pupate. Adults emerge after a few weeks to several months depending on temperatures, to repeat the reproductive process. Adults become sexually mature in a few days and oviposition begins soon after mating is accomplished. Periods of cessation of growth and development, called diapause, are not known and multiple generations occur annually. Adult life span in *A. ludens* is comparatively long and may reach a year or more (Darby and Kapp 1934).

The hosts utilized by *A. ludens* cover a wide range of citrus, mango, stone and pomaceous fruits (Baker, et al. 1944). Adult flies seek suitable hosts throughout the year and dramatic fluctuations in population size can occur repeatedly. Thus, host availability and suitability become the major regulator of final population size (Malavasi and Morgante 1982). *A. ludens* can disperse rapidly and become a serious pest where it is already established due to the variety of hosts attacked, the large biotic potential (more than 400 eggs during female life span (McPhail and Bliss, 1933), and adult longevity of up to a year.

Federal quarantines of known hosts were enacted to prevent spread of *A. ludens* in infested commodities. Among citrus varieties, only lemons and sour limes are exempt as hosts; grapefruit, on the other hand, is well known as a preferred host for this fly. Federal Quarantine No. 5 denies entry of citrus hosts, mangos, peaches, plums and other known subtropical host fruits from Mexico into the United States unless treated to disinfest the commodities. Similarly, Federal Quarantine No. 64 prevents certain fruit from several Texas counties being sent to other parts of the U.S. except as certified pest free by the USDA (see Ebeling 1959).

POTENTIAL FOR SPREAD. Exotic pests from tropical regions that have become established in the United States were often aided by the erroneous assumption that our climates would be too hostile for their survival. Species of fruit flies can be counted among the examples. A widely held opinion regarding the Caribbean fruit fly, *A. suspensa* (Loew), when detected in Florida, was that populations could not survive the northerly range. *A suspensa* currently infests a citrus growing region of 850,000 acres and causes some 25 million dollars in losses each year. More than 50 hosts, including grapefruit, peach, Surinam cherry, guava, mango, loquat and other citrus varieties have been recorded (Mitchell, et al. 1977). More recently, the 1980-82 outbreak of Medfly, *Ceratitis capitata* Weid., in Santa Clara county, California occurred in an area that, based on environmental chamber experiments (Messenger and Flitters 1954), was outside a suitable region of survival within the U.S. The medfly was eradicated in 5 counties with bait sprays, but the sterile fly release that preceded and the spray program cost ca. 100 million dollars.

Insight into adaptive mechanisms of tephritid fruit flies has been recorded from fruit fly research in Australia. The Queensland fruit fly, *Dacus tryoni* (Froggart), was originally restricted to patches of tropical and subtropical rainforest along the east coast of Australia where reproduction and development was continuous (Fletcher 1973). In the last century its migration into cultivated fruits over a much larger area of eastern Australia required adaptation to very different climatic conditions from its ancestral habitat. Only adults are known to overwinter in climatic extremes but the study of adaptive mechanisms in sexual development and maintenance of energy reserves (Fletcher 1975) amply demonstrate the potential of this and related tephritid species to adapt to regions where their hosts are successfully grown.

Natural spread is most significant in incipient infestations that have already become established. More important is the quantum advances exotic pests may accomplish along commercial routes in airplanes, ships or surface carriers. Fruit fly interception at U.S. ports of entry from Central America and Panama are shown in Table 1. The Mediterranean fruit fly, *C. capitata* and two Anastrapha species, *A. ludens* and *A. obliqua* (Macquart), are illustrative of the species involved. U.S. borders are constantly being challenged and tropical fruit flies with their wide host preference pose a serious

Table 1. Samples of Fruit Fly Species Interceptions at U.S. Ports of Entry from Central America and Panama, 1964-1972.

Point of Origin	1964	1965	1966	1967	1968	1969	1970	1971	1972
Belize									
Crititis capitata									
Anastrepha ludens			X	X		X		X	X
A. obliqua						X		X	
Costa Rica									
C. capitata	X			X	X	X		X	
A. ludens									
A. obliqua	X	X	X	X	X	X		X	X
El Salvador									
C. capitata					X				
A. ludens				X	X	X	X		
A. obliqua	X	X	X	X	X	X		X	X
Guatemala									
C. capitata									
A. ludens	X			X	X	X	X	X	X
A. obliqua	X	X	X	X	X	X		X	X
Honduras									
C. capitata								X	X
A. ludens					X		X	X	X
A. obliqua	X	X	X	X	X			X	X
Nicaragua									
C. capitata	X								
A. ludens						X	X		
A. obliqua	X	X	X	X	X	X			X
Panama									
C. capitata					X	X			X
A. ludens					X				
A. obliqua		X		X	X	X		X	

(Source: USDA. "x" indicates one or more interceptions.)

threat to the fresh fruit and vegetable industry. Fruit fly interceptions are made hundreds of times each year at U.S. Ports of Entry. Four states, (Arizona, California, Florida and Texas) produce most of the U.S. commercially grown citrus. Only Arizona has escaped costly eradication programs necessary to eliminate Medfly from the other states. A sterile insect program is currently underway in Texas aimed at eradicating the Mexican fruit fly and plans are being formulated to eliminate the Caribbean fruit fly from Florida. Nine states produce peaches that account for 81 percent of U.S. production--Alabama, Arizona, California, Florida, Georgia, Louisiana, Mississippi, South Carolina and Texas. Losses were projected, at 1975 prices, to exceed 70 million dollars if less than 20 percent of the total crop of citrus were destroyed and 1.1 million for peaches (Mitchell, et al. 1977). These projections suggest that establishment of *A. ludens* would be catastrophic until control practices and commodity treatment systems were developed and implemented.

PREVENTING LOSSES AND SPREAD, PAST AND PRESENT APPROACHES AND FUTURE POSSIBILITIES. A synopsis of options either in use or the focus of ongoing state, federal and private research is presented in Table 2. The level of intervention required denotes the frequency for application of the various technological approaches to reduce losses and prevent spread. Intrinsic value is an assessment of the current worth and acceptability within present technocracy. Corresponding technological approaches are categorized to illustrate: 1) future possibilities potentially available from scientific endeavor (good), 2) technology currently used or available as an alternative (acceptable), or 3) more drastic approaches less useful to maximum productivity and quality (negative).

Technology approaches. The following discussion is in reference to Table 2: Continuous application of technology would be required in part A to reduce the risk of spread.

A1. Yet to be clearly determined are the mechanisms of host plant susceptibility and resistance to fruit fly invasion. Mature to fully ripe fruit, among cultivated-crop hosts, is commonly preferred by female fruit flies as oviposition sites. Harvesting fruit prior to population buildup in mature fruit or prolonging the resistance mechanisms in young or non-host fruits offer promise as cultural control approaches. The use of gamma rays to prevent spread in commerce might also become a viable and economically feasible alternative to the use of insect toxicants. The probability of successful and environmentally safe application warrant accelerated research in this area.

A2. Currently, advances in the use of proteinaceous bait sprays containing a toxicant, malathion, provide a high degree of fruit fly specificity aimed at controlling the adult population. Reduction of adult fruit fly populations is augmentary to quarantine security sought by fumigation or other physical treatments to disinfest fruit. This approach is presently used against *A. ludens* attacking citrus in Mexico.

A3. Strictly enforced quarantines prohibiting movement of commodities from infested areas would have a negative impact on distribution of fresh fruit commodities and the industry. Such action is always the last resort and certainly not a method of choice by regulatory agencies.

The approaches described in part B are more directly aimed at suppressing the pest so that only periodic intervention would be required.

Table 2. Synopsis of Alternative Procedures to Reduce Losses and Prevent Spread of Fruit Flies.

Level of Intervention Required	Technical Approach	Intrinsic Value
A. Continuous	1. Cultural techniques/irradiation disinfestation	Good
	2. Prescribed pesticide and fumigant application	Acceptable
	3. Strictly enforced quarantine	Negative
B. Periodic	1. Biological control	Good
	2. Sterile insect technique eradication/containment	Acceptable
	3. Region-wide bait spray application	Negative
C. None	1. Resistant hosts	Good
	2. Species selection	Acceptable
	3. No treatment	Negative

B1. If an efficient antagonist or complex of biocontrol agents were available that could remain viable under conditions of very low fly population levels, then periodic reintroduction of biologically active controls might suffice to contain or eliminate the risk of spread. For example, little is known about soil born pathogens that attack mature larvae or pupae during a vulnerable period of development in that environment. Clausen (1978) reported the successful introduction of *A. ludens* parasites in several states in Mexico resulting in a substantial reduction of fruit infestation. Additional search for pathogens and parasites is an important facet of citrus insect control.

B2. The sterile insect technique must be scientifically evaluated as a means of eradication and containment of several species of tephritid fruit flies. This approach, if effective, may be well suited to the elimination of *A. ludens* from the Lower Rio Grande Valley of Texas when used in conjunction with other suppression methods. If successful, when coupled with efforts to contain migration or introduction from Mexico, it is conceivable that extended fly free periods could be maintained. An important benefit of such technology is the target specificity, i.e., the balance of other pest management systems in the variety of host crops would be least disturbed by release of sterilized flies. Continued research is necessary to improve fly quality and economical production of flies for sterilization and release. Moreover, the need for more effective attractants and traps remain a high priority for detection and population monitoring, particularly for *Anastrepha* spp.

B3. Region wide bait spray programs would be cost prohibitive and environmentally hazardous at the frequency required to approach eradication. This approach contrasts with population redirection (A3. above) in its use as a population eradication method over the entire habitat. If a powerful attractant were available for *Anastrepha* spp. that could be effective against one of the reproductively active sexes, then the value would be upgraded. Male annihilation technology is effective against *Dacus dorsalis* Hendel, the Oriental fruit fly, because the male fruit fly is stimulated to respond and feed on the attractant methyl eugenol, even when laced with a toxicant (Knipling 1979). The widespread, frequent use of insecticides would likely not find acceptance until such compounds are discovered for *A. ludens.*

Finally there are alternatives for which no intervention would be required but with concomittant sacrifice of the purpose of fresh fruit production and commercialization. Otherwise, a long developmental period would still have to be bridged.

C1. Genetic selection of cultivars resistant to fruit fly attack, given concentrated study, could in time provide an alternative. The potential and probabilities for this development in known hosts of fruit flies remains virtually unknown and at best would be a long term task.

C2. Selection of non-host crops is a management decision largely governed by economics of control cost versus profit. The high biotic potential and high populations of fruit flies in some areas warrant consideration of this alternative.

C3. The option to do nothing toward preventing losses and increased spread of highly destructive fruit flies appears inappropriate. Nevertheless, it could be assumed that in time, with advances in rapid transportation, increased travel and trade, that those species with adaptive capacity will ultimately reach their limits. The record of curtailing such advances onto the north American continent, however, reveals the enormous savings in production of high quality products. If only processed products were allowed, i.e., juice, that contained no live insects (only parts); only then, perhaps, would a "do nothing" approach be acceptable.

CONCLUSIONS

The Mexican fruit fly, *A. ludens,* belongs to the group of tephritid fruit flies ranked among the world's most economically important pests. Survival mechanisms have evolved that permit explosive populations to occur during relatively short periods of host availability. Further, a given species may infest from several to hundreds of different hosts in a continuing process of adaptation to new environments. Modern approaches, such as the sterile insect release method may offer advantages toward eradicating the Mexican fruit fly and providing protection against establishment of other destructive species such as the Mediterranean fruit fly, *C. capitata* in the Lower Rio Grande Valley.

Competition with fruit fly pests for fresh fruit commodities will require a multifaceted commitment of science to provide biologically sound and environmentally safe strategies. Past achievements in eradicating and controlling these pests within the United States provide an optimistic viewpoint for maintaining our present successes and improving our security against future invasion.

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Testing Subtropical Deciduous Fruit Clones for Texas' Lower Rio Grande Valley

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Additional Index Words. Peach, nectarine, plum, apple, **Prunus persica,** low-chilling.

ABSTRACT

Low-chill deciduous fruit tree clones of peach, nectarine, plum and apple are being evaluated for adaption to subtropical climatic conditions. Peach cultivars developed in the past 5 years are promising for commercial production in the Lower Rio Grande Valley of Texas and areas with similar subtropical climates. Peach, nectarine and plum clones which possess characteristics acceptable in U.S. markets and ripen in April and May are being tested. Low-chill apple cultivars are being evaluated primarily for use in homeowner and landscape planting.

A deciduous fruit tree (peach, nectarine, plum, apple) must experience a certain amount of cool temperature during the winter for leaf and flower bud dormancy to be broken to allow normal growth to resume in spring. This 'chilling' requirement is measured in units. A chill unit is the maximum amount of chilling that can be satisfied in one at an optimum temperature. The optimum temperature for chilling in most peach cultivars has been established at 7 °C (45 °F). Subtropical short-cycle, low-chilling peach cultivars acquire chilling at higher temperatures, although the quality of such chilling with some cultivars may not be as good.

Low-chill peach cultivars have been introduced into the United States during the past 100 years from South China. Fruit has generally been small, soft when ripe, poorly shaped, and have ripened too late for the early market. Peach breeding to improve low-chill cultivars began in California in the early 1900's and later in Florida and Texas (1,7,8).

Peach cultivars developed in the last 5 years are promising for commercial production in the Lower Rio Grande Valley of Texas (2,4,5,12) Central Florida, and areas around the world with similar subtropical climates (9,10,11). Subtropical climatic regions need peach, nectarine and plum cultivars with chilling requirements not exceeding about 200 chill units. Subtropical peach cultivars for commercial production adapted to the Lower Rio Grande Valley have been reported (3,6).

Approximately 500 acres of low-chill peaches are currently established in the Lower Rio Grande Valley. Indications are that additional acreage will be planted in the next few years as more growers become interested in peaches and the potential for this new crop is demonstrated.

The objective of the program at the Texas Agricultural Experiment Station (TAES), Weslaco, is to test low-chill peach, nectarine, plum, and apple clones that may be adapted to the subtropical climate of the Lower Rio Grande Valley. The goal of the program is to recommend cultivars that have demonstrated commercial potential in this subtropical climate and to make available through cultivar release new selections found to be superior to cultivars currently available. Selections found to be adapted here should also be adapted to similar climatic areas of the world's subtropics and tropical highlands. Five cultivars have been recommended to growers since the project began, 2 of which ('FlordaGrande' and 'TropicSweet') are cultivar releases made possible by this project.

Selections for testing are obtained from the breeding programs at Texas A&M University, University of Florida, California, and other sources of suitable germplasm. Some selections tested in this program have been named and released by others before our evaluation has been completed. Some selections not found suitable for U.S. markets were named in areas where they had local use. Fruit standards in other countries differ from U.S. markets which demand fruit size over 5 cm (2.0 inches), round fruit shape with exterior red color and high fruit firmness. Different geneotype expressions occur in other climates. For example, more red peel color is noted in desert climates and smoother fruit surface texture occurs with consistent cool spring temperatures during fruit development. In areas that warm up quickly in the spring and maintain warm growing temperatures, fruit development time and thus days to maturity is less and fruit have less tendency for blossom-end protuberance.

Evaluation characteristics in the peach, nectarine and plum testing program include: chilling requirement, tree form and structure, flower bud set and thinning requirements, bloom dates and fruit characteristics. Fruit characteristics being evaluated include fruit developmental period, fruit maturity, fruit color, fruit shape, fruit firmness, fruit taste, resistance to flesh browning and resistance to bacterial leaf spot [*Xanthomonas campestris* pr. *pruni* (Smith) Young et al.]. Bacterial spot is being evaluated by cooperators in Florida as this disease has not been identified as a problem in the Lower Rio Grande Valley. Resistance to this disease is considered important and test selections are evaluated as this is the only disease resistance currently shown to be improved through breeding.

Chilling requirements of test selections are determined by comparing bloom and leaf bud break dates with known cultivars to give an estimate of chilling. Flower density and bud set data indicate the production potential of the selection. Tree growth habit identifies those trees that require more pruning to achieve desired tree shape and may experience limb breakage with heavy fruiting. Thinning is necessary with all cultivars to produce marketable size fruit. Fruit size is influenced by genetic potential, crop load, days from bloom to fruit maturity, and cultural management. Breeding programs with low-chill clones strive to combine early maturity with large fruit of high quality.

Fruit shape, firmness, peel and internal color, taste, and resistance to flesh browning and resistance to bacterial leaf spot are all subjectively evaluated. Round fruit without protuberances or suture bulges receive highest ratings. Fruit which ripen

Table 1. Peach cultivars and peach and nectarine test selections that show adaption to subtropical climatic areas similar to the Lower Rio Grande Valley.

Cultivar	Observed (yrs) FL	TX	Estimated chill units	FDP[z] (days)	Size(g)	Stone freeness
Peach						
EarliGrande	12	6	200	75	90	semifree
Flordaprince	8	6	150	80	88	semifree
Desertred	5	2	175	88	101	semifree
TropicSweet	10	5	175	95	111	free
FlordaGrande	12	5	75	100	98	semifree
Rayon	7	5	150	105	109	semifree
Fla. 8-1	8	2	200	69	72	semifree
Fla. 9-20C	5	2	225	111	85	cling
Fla. 82-12	3	2	175	78	112	semifree
Fla. 82-19	3	2	250	70	85	semifree
Nectarine						
Fla. 9-6N	5	2	225	89	87	semifree
Fla. 9-8N	5	2	250	89	104	semifree
Fla. 9-11N	5	2	175	95	92	semifree
Fla. 9-12N	5	2	250	91	85	semifree
Fla. 9-15N	5	2	275	88	97	semifree
Fla. 82-23N	3	2	250	89	100	free
Fla. 81-17N	4	2	125	95	90	semifree

[z]Fruit development period from full bloom to ripe.

unevenly or lack firmness at the time of harvest are unacceptable for commercial use. Red peel color is desirable in U.S. markets and cultivars with bright red color usually receive the best prices. White internal color is not desired in U.S. markets and white peaches have had poor shipping characteristics. Fruit taste is scored highest for high aroma, high acid, high sugar, and a balanced sugar/acid ratio. Cultivars that bruise easily or have flesh that brown and darken easily when exposed to air are unacceptable.

Recently released peach cultivars and promising test selections are shown in Table 1. The selections being evaluated possess characteristics acceptable in U.S. markets and ripen in April or May.

There is no commercial quality nectarine adapted to the subtropical climate of the Lower Rio Grande Valley. Several are being tested that offer promise for future release (Table 1). Presently only 'Sunred' is suitable for dooryard planting.

A suitable subtropically adapted plum cultivar has not been found. Low-chill plums are hybrids of the American plum with the Japanese plum. Problems to overcome with low-chill subtropical plums are small size, susceptability to windscar, and self-infertility requiring pollinizers. Plum clones being evaluated which may be suitable for homeowners are shown in Table 2.

Apple cultivars being evaluated for adaptability to subtropical South Texas are shown on Table 3. Several of the Israeli apples will grow and fruit successfully in the Lower Rio Grande Valley, maturing fruit from mid-June through July. No commercial future is expected because they cannot compete in the market place with the year-round availability of apples from controlled atmosphere storage. 'Anna' and 'Dorsett Golden' are of best quality. 'Anna' is a red fruit shaped similar to 'Red Delicious'. 'Anna' requires a pollinizer, for which 'Dorsett Golden' is a good choice. Both cultivars can be successfully grown on dwarfing apple rootstocks, allowing them to be used for homeowner and landscape planting.

Table 2. Plum clones being evaluated for adaption to subtropical climatic areas similar to the Lower Rio Grande Valley.

Cultivar	Estimated chill units	Comment
1-2 (8-2)	250-275	Gulfruby, high ratings, requires pollinizer
3-4	300-350	Gulfgold, observations incomplete
3-5	300-350	Observations incomplete
8-1	200	Observations incomplete
85-1	150	Observations incomplete
85-3	150	Observations incomplete

Table 3. Apple cultivars being evaluated for adaption to subtropical climatic areas similar to the Lower Rio Grande Valley.

Cultivar	Peel color	Comment
Anna	red	Acceptable for home, needs pollinizer
Dorsett golden	gold	Acceptable for home, pollinizer for Anna
Ein Shemer	gold	Fair quality
Slor	green	Fair quality
Michael	green/red blush	Fair quality
Maayan	red	Fair quality
Adian	green/red blush	Poor quality
Elah	green	Poor quality, very late maturity

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Damage and Control of *Thrips tabaci* Lindeman on Spring Onions

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ABSTRACT

Yield in fall-planted onions *Allium cepa* L. cv. 'Texas Grano 1015 Y' was inversely related to onion thrips *Thrips tabaci* Lindeman, populations in an experiment conducted in 1984-85. A 1.8 percent yield loss was determined when an average of one thrips per plant was present throughout the growing season. Thrips populations were not adequately controlled with any of the labeled insecticides, but the unlabeled insecticide, cypermethrin, provided good control. The use of and possible limitations of low volume insecticide application methods is considered.

The onion thrips is the principal arthropod pest of onions grown in the Lower Rio Grande Valley (1, 2, 5). Thrips rasp plant leaf tissues and feed on the exuded plant fluids, resulting in damage. Damage symptoms include leaf curl, tip dieback, and a silvery appearance in the leaves. Commercial onion producers commonly treat infested fields with insecticides 3 to 10 times per season.

Previous attempts to relate yield loss to thrips infestations have met with inconsistant results (4, 6, 7), and Harding (3) concluded that improved varities, coupled with changing cultural practices, reduced the impact of thrips feeding on yields. Recent producer-based reports of heavier thrips infestations in commercial fields in the Lower Rio Grande Valley, coupled with the availability of new high yielding onion varieties, have aroused renewed interest in evaluating thrips impact on onion yield. Additionally, producers are reporting that registered insecticides do not control thrips as well as in the past. These studies were begun to (1) determine the impact of thrips feeding on onion yield, and (b) to evaluate labeled and unlabeled insecticides for control of onion thrips using application volumes representative of common commercial practices.

MATERIALS AND METHODS

Yield Impact Test: Experiments were conducted on an Hidalgo sandy clay loam soil at the Texas Agricultural Experiment Station Annex, Mercedes, Texas. 'Texas Grano 1015 Y' onions were seeded at a population of 35 seeds/m of row on November 5, 1984 into 100 cm (40 in) beds each containing two rows spaced 25 cm (10 in) apart. Onions received a side-dress application of urea at 67 kg/ha (60 lb/acre) on February 20, 1985, and chlorothalonil was applied at 1.3 kg ai/ha (1.2 lb ai/acre) on March 20, and 24 and April 4, 12, and 23, 1985, to control purple blotch,

Alternaria porri (Ell.) Cif. The field was divided into plots measuring 10 m (30 ft) by two beds and arranged in a randomized complete block design with five replications per treatment. Methomyl was used as the insecticide treatment and applied at 0.56 kg ai/ha (0.5 lb ai/acre) with a CO2 powered back-pack sprayer in 48 1/ha (5.0 gal/acre) of water. Treatments consisted of the following: 1) no methomyl applications; 2) mid-season applications [applied on March 15, 21, and 27, and April 4 and 12]; 3) late-season applications [applied on April 12, 18, and 27 and May 1]; or 4) season long applications [applied on March 15, 21, and 27 and April 4, 12, 18, and 27, and May 1].

Thrips populations were evaluated using the method described by Edelson (1). Three randomly selected plants per plot were visually inspected for thrips three days following methomyl applications. At maturity, onions were lifted from the soil and allowed to dry for 2 days, then the bulbs were trimmed of leaves and roots and weighed to determine yield. The seasonal mean number of thrips per plant was calculated for each treatment, and yield (kg/m-row) was regressed on that mean.

Labeled Insecticide Test: Six registered insecticides were evaluated for thrips control in a replicated experiment. Experimental methods were the same as in the Yield Impact Test with the following exceptions: 1) each plot measured 9.5 m (30 ft) by two beds, and was bordered by one bed of a wheat-barley grass mix in order to reduce drift; 2) treatments were applied on April 4, 12, 17, and 23, 1985 through a CO2 powered, tractor-mounted spray boom in a total volume of 102 1/ha (11 gal/acre); 3) sample size was three randomly selected plants per plot for the first three sample dates, but was increased to five and 10 plants per plot for the last two samples respectively as thrips populations began to decline. Data from each plot were pooled across the season, and seasonal means were subjected to analysis of variance. Treatment means were separated using Duncan's Multiple Range Test.

Unlabeled Insecticide Test: Ten unlabeled insecticides were evaluated for thrips control. Methods were the same as described in the Labeled Insecticide Test with the following exceptions: 1) experimental design was a randomized complete block with four replications; 2) plot size was 12.2 m (40 ft) by two beds wide; 3) treatments were applied on April 18 and 26, 1985 with a CO2 powered backpack sprayer calibrated to dispense 86 1/ha (10 gal/acre) or 216 1/ha (25 gal/acre) respectively; 4) sample size was three randomly selected plants per plot for the first two samples (April 15 and 22) and was increased to 10 plants per plot for samples collected on April 25 and 30 as thrips populations declined.

RESULTS

Yield Impact Test A statistically significant ($p = 0.05$) regression coefficient was calculated describing a negative linear relationship ($Y = 11.4 - 0.2X$, $R2 = 0.98$, $n = 4$) between yield in kg/m2 (Y) and the seasonal average number of thrips present per plant (X). The coefficient indicates a 1.8% loss of onion yield occurred when an average of one thrips was present on each plant for 72 days (Figure 1).

Labeled Insecticide Test: An average of 45 thrips per plant were present on the pretreatment count taken April 3. Thrips populations were declining as treatments were applied, resulting in lowered populations in the untreated plots. As plants entered senescence, thrips populations declined which resulted in high variability within treatments. Thrips were not controlled by any treatment ($p = 0.10$) under the conditions

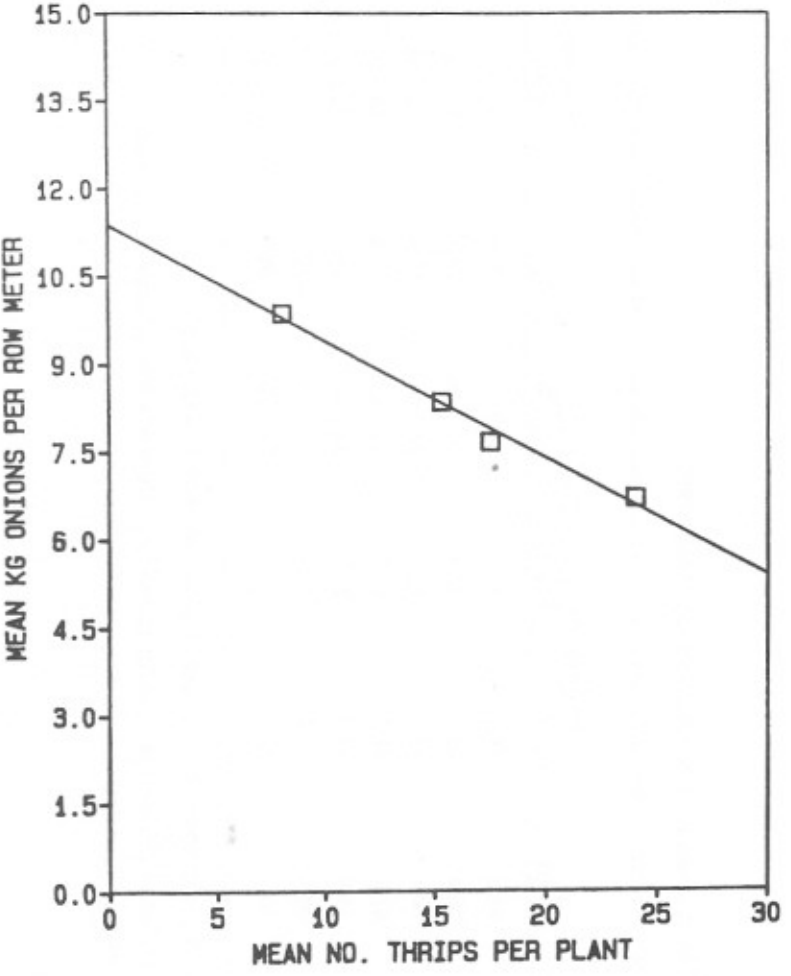

Fig. 1. Relationship of onion yield (kg) per row meter to the mean number of thrips per plant.

of the experiment, however thrips numbers were numerically lower in plots treated with methomyl (Table 1).

Unlabeled Insecticide Test: Thrips counts averaged 55 per plant prior to insecticide application. Pooled data indicated that cypermethrin ($p\ F=0.10$) reduced thrips populations compared to the untreated plots. Plots treated with bifenthrin, avermectin B1, cyfluthrin, acephate, fluvalinate, carbaryl, and permethrin, had numerically lower thrips populations, although they were not statistically different from the untreated plots. The data reflected the high variability of thrips counts within treatments, and the resulting lack of statistical separation between treatment means.

Table 1. Effect of registered insecticides on *Thrips tabaci* L. in onions, Weslaco, Texas, 1985.

Treatment	Rate ai/ha (kg)	Mean Number of Thrips/Plant*					Seasonal Mean
		Apr 03	Apr 15	Apr 22	Apr 26	Apr 29	
diazinon 4EC	0.56	44.5	48.3	24.9	36.3 a	25.6	32.2 a
malathion 57% EC	1.08	50.5	68.8	23.4	26.7 ab	26.8	31.3 a
Mevinphos 4EC	0.56	44.4	63.2	15.1	21.1 ab	19.6	24.7 ab
azinphos-methyl 2L	0.56	43.1	41.7	17.7	35.6 a	21.1	28.7 a
methyl parathion 4E	0.56	51.9	40.7	22.0	20.1 ab	18.5	22.2 ab
methomyl 1.8 EC	0.50	40.9	26.1	21.7	9.4 b	19.5	16.7 b
untreated	---	44.3	39.2	22.5	17.0 ab	20.0	21.3 ab

*Mean of three plants/plot on 4/03, 4/15, five plants per plot on 4/22, and 10 plants per plot on 4/26, 4/29.

Means followed by the same letter are not significantly different (P = 0.10) according to Duncan's New Multiple Range Test.

Table 2. Effect of non-registered insecticides on *Thrips tabaci* L. in onions, Weslaco, Texas, 1985.

Treatment	Rate ai/ha (kg)	Mean Number of Thrips/Plant*				Seasonal Mean
		Apr 15	Apr 22	Apr 25	Apr 30	
chlorpyrifos 50 WP	0.56	78.4	14.8	17.9 a	16.3	16.8 a
oxamyl 2L	0.56	51.2	10.5	15.0 ab	6.3	10.6 b
permethrin 2E	0.22	44.3	14.6	7.7 cd	10.1	9.7 b
carbaryl 4EC	1.12	71.3	8.4	7.9 cd	7.7	7.9 bc
fluvalinate 2E	0.11	42.2	14.7	6.7 cd	9.4	8.9 b
acephate 75 SP	0.56	49.6	8.3	4.9 d	11.2	8.1 bc
cyfluthrin 2.4EC	0.05	49.4	5.5	6.8 cd	7.1	6.8 bc
avermectin B1	0.02	65.9	9.8	7.0 cd	4.4	6.2 bc
bifenthrin 2 EC	0.06	59.1	5.5	8.5 cd	5.5	6.8 bc
cypermethrin 2.5EC	0.09	60.6	3.0	4.0 d	1.8	2.9 c
untreated	---	42.1	17.4	11.9 bc	6.1	10.1 b

*Mean of three plants/plot on 4/15, 4/22, and 10 plants per plot on 4/25, 4/30.

Means followed by the same letter are not significantly different (P = 0.10) according to Duncan's New Multiple Range Test.

DISCUSSION

The data clearly demonstrated a relationship between thrips populations and yield reductions, connoting that thrips should be controlled to maximize yields. Satisfactory reductions of thrips populations were not obtained with any labeled insecticide treatment using low volume application methods. Shelton (personal communication) demonstrated that volumes of 48 to 96 l/ha (5 to 10 gal/acre) were not effective in delivering an insecticide to the base of an onion plant where onion thrips feed. Furthermore, he indicated that coverage could be increased 4 to 6-fold at volumes of 327 to 935 l/ha (35 to 100 gal/acre). We have noted that immature thrips aggregate at the base of onion plants, and hypothesize that this behavior allows them to escape contact with an insecticide material that does not reach the base of the plant. Currently, there is some indication that thrips may be tolerant to insecticides already registered on onions, but toxicological data is needed to demonstrate and quantify it. Cypermethrin is an effective material based on results of the unlabeled test, even when applied at low volumes. Future research needs include a closer examination of the relationship between thrips and yield, evaluation of insecticide application methodologies, and clarification of the economics of thrips population management.

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Insect Growth Regulators and Plant Extracts for Control of Leafminer

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Insecticidal control of leafminers in the genus *Liriomyza* Mik has become increasingly difficult during the last 15 to 20 years. Hints of development of resistance to synthetic insecticides (organophosphates, carbamates, chlorinated hydrocarbons and pyrethroids) was first noted in 1957 (3). Reports of possible leafminer resistance to many insecticides have been noted throughout the United States as well as other countries. *Liriomyza trifolii* (Burgess) is one of the most damaging species in the *Liriomyza* complex and of concern in the Lower Rio Grande Valley. It has been observed to have an ca. 20-fold resistance to permethrin on chrysanthemum in California (6). High levels of resistance to other groups of synthetic insecticides is likely. Once a new insecticide is introduced its effective field life is very shor (estimated at ca. 3 years in Florida (5)). In general, no synthetically produced labele insecticide provides control. In addition to the development of resistance, syntheti insecticides have been linked to the destruction of beneficial insects, i.e. parasites which led to increases in leafminer populations. It is also plausible that subleth doses of many compounds, such as chlorinated hydrocarbons, may exe physiological effects which are carried over from one leafminer generation another. These effects may include increased fecundity and longevity of the inse

To understand the reasons for the increased levels of resistance with *L. trifolii* o must understand its basic biology and ecology. *L. trifolii* is polyphagous, feeding many different weed and commercially grown plant species. It survives well on su common weeds as pigweed (*Amaranthus palmeri* S. wats), ragweed (*Parthen hysterophorus* L.) and common sunflower (*Helianthus annuus* L.). Plant dam occurs by either adult strippling of the leaf surface for feeding and/or ovipositi and larval feeding or tunneling through the upper leaf cellular level (mesophyll). latter results in a characteristic mined appearance on the leaf. In order to feed c wide variety of plants the metabolic processes of the insect must be highly flex and efficient. These same metabolic processes are used to de-toxify var chemicals, such as insecticides, that the insect may come in contact with. In addi to its wide host range, *L. trifolii* has a fairly short generation time of ca 21 da 78 °F (Chandler, unpublished data). This allows several generations of the inse develop within a single growing season. The short generation time increase

likelihood of exposure of the insect population to various insecticides. Increased survival pressure due to frequent insecticide exposures, short generation times and ability to de-toxify chemicals could all account for the increased incidence of insecticide resistance reported in this insect.

If the incidence of resistance to many of the available insecticides is high, what is the chance of finding an effective compound that will last? One's first inclination is to say slim at best. However "third generation pesticides" have provided some hope. Third generation pesticides can be broadly defined as bioactive compounds that include insect growth regulators, juvenile hormone analogs, and chitin inhibitors. These compounds alter the normal growth patterns of insects in various ways and result in their death. Some are synthetic compounds while others are derivatives of natural products. Other insecticides, while similar to insect growth regulators in concept, act as disruptors of neuropathway activity resulting in paralysis and eventually death. In either case the modes of action of the compounds are unique, often selective to only certain insect species, and appear not to persist in the environment. All of these benefits enable these compounds to be used in a management program designed to decelerate or even prevent development of resistance. With this in mind, I would like to discuss the characteristics, effectiveness and use potential of three "third generation pesticides" against *L. trifolii.*

At present, Trigard, or Larvadex, is the only labeled insect growth regulator for use on vegetables that is efficacious against *L. trifolii.* It is also known as cyromazine and is a substituted melamine (1). The product is currently manufactured by Ciba-Geigy Corporation. Trigard is a larvacide with its greatest period of activity just prior to pupation. If pupation occurs the insect fails to develop into an adult. The exact mode of action of the material is unknown. Evidence suggests its larvicidal effect is not based on direct interference with cuticle formation and/or chitin deposition. It may act at the hormonal level to retard larvae growth resulting in the inability to moult and eventually death. Trigard is formulated as a 75% WP (wettable powder) and is applied as a foliar spray at the rate of 1/8 lb a.i./acre. Trigard applied in this manner results in high levels of contact activity. Its effectiveness against leafminer larvae within a leaf is a result of the material being absorbed into the plant tissue where the larvae ingest it as they feed. The material, though, is not systemic. Currently, a Section 18 labeling of the product for use on peppers exists in Texas and expires in June 1986. Two to three applications, 7 days apart, may be necessary for control. Phytotoxicity has not been reported. It has an oral and dermal LD50 of well over 2000/mg/kg resulting in minimal human toxicity problems. At present no cases of resistance to this compound have been reported.

Another compound with great control potential, but as yet not registered for use, is abamectin. This compound is produced by Merck Sharp and Dohme. Abamectin is a mixture of two biologically active homologous avermectin components derived from the natural product, macrocyclic lactone, of the soil microorganism *Streptomyces avermitilis* (2). Avermectins have a broad spectrum of activity against mites, insects and nematodes. Abamectin contains a minimum of 80% avermectin B_{1a} and a maximum of 20% avermectin B_{1b}. When ingested by the target organism, abamectin affects neural transmission mediated by gamma aminobutyric acid (GABA), an inhibitory neurotransmitter. It stimulates GABA release, thus interrupting nerve impulses resulting in insect paralysis and death. Some contact activity has also been noted and the chemical has translaminar movement in the plant which allows the material to

Table 1. Mean number of *L. trifolii*/plot, on bell peppers, Weslaco, TX.

Insecticide	Rate (KG A.I./HA)	Larvae/plot[a/] Pretreatment	14 day posttreatment
Abamectin	0.01	45.3	21.0b
Trigard	0.14	37.3	14.7b
Cygon	0.37	44.3	121.7a
Pydrin	0.22	44.0	140.3a
Monitor	0.84	38.3	114.3a
Control	-	45.0	117.7a

[a/] Means separated by Duncans Multiple Range Test (P = 0.05).

come in contact with feeding leafminer larvae. On plant surfaces abamectin dissipates rapidly. Within plant tissue, however, the residual activity of the compound is relatively long. Little phytotoxicity has been observed and human hazard is minimal. It has an oral LD50 of 650 mg/kg and a dermal of > 2000/mg/kg. It is toxic to honey bees. In addition to leafminers, abamectin has proven effective in controlling citrus rust mite, citrus red mite, carmine spider mite, green peach aphid, tomato pinworm, Colorado potato beetle and codling moth as well as many other insect and mite species (2).

The effects of Trigard and abamectin on *L. trifolii* populations in bell peppers are briefly presented in Table 1. As noted, both insecticides significantly limited the total number of *L. trifolii* larvae on 25 mature pepper leaves per plot 14 days after initial application. Cygon, monitor and pydrin did not provide control. It is evident that some degree of leafminer resistance to organophosphates and permethrins is present in the Lower Rio Grande Valley.

An interesting compound now being evaluated for field use on *L. trifolii* on vegetables is neem seed extract. Neem trees, *Azadiracta indica* A. Juss (Meliaceae), are widely distributed throughout India, Pakistan and parts of Africa (7). The plant has a variety of uses and has been introduced into Cuba, Pakistan and southern Florida. In addition to being an insecticide, the seed extract is used to treat skin disease, sores, ringworms and rheumatism. Other plant parts are used for soap and toothpaste. The seed extract is composed of many phagorepellents (antifeedants), and one of the more well known is azadiractin. This compound is a terpenoid with four components in proportions of: 1 azadiractin D; 100 azadiractin A; 50 azadiractin B; and 1 azadiractin C. (7). When fed upon it inhibits insect development, reduces egg laying and may even disturb the neuroendocrine system. The latter regulates ecydyson and juvenile hormone synthesis. Neem seed extract is absorbed by the plant and appears to have systemic activity. In addition to *L. trifolii*, neem seed extract has activity against many pests including Japanese beetles, mosquitoes and roaches (7). Currently, neem seed extract has a conditional EPA registration for leafminer control on

greenhouse ornamentals. The commercialization is being pursued by Vikwood, Ltd of Shebogan, Wisconsin. Larew et al. (4) has shown the control potential of neem applied as a soil drench in a commercial chrysanthemum greenhouse. Though not as efficacious as Trigard, neem did significantly limit the number of adult leafminers reared from pupae and is an acceptable alternative for use on *L. trifolii*. Trials in the Lower Rio Grande Valley (Chandler, unpublished data) show that neem has some activity when applied as a soil drench to bell peppers in a 0.1% solution. Further work is needed to determine rates, timing of applications and effective application methods.

In conclusion, though future control prospects of *L. trifolii* at times appear bleak, there are certain compounds that can provide some assistance to growers. However, the use of compounds such as Trigard, abamectin and neem is by no means a panacea. No one knows how long it will be before resistance to these compounds develops. Cases of resistance to other insect growth regulators have been documented (8). For example, Methoprene resistance has developed in the house fly and various mosquito species (8). Growers and others faced with controlling *L. trifolii* on various vegetables should be aware of the potential formation of resistance by the insect to these compounds. However, current research on the biology and ecology of *L. trifolii* being conducted throughout the United States should aid in understanding the pest and how best to manage it without suffering significant economic loss.

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Biology and Control of a Carrot Weevil in the Lower Rio Grande Valley, Texas

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ABSTRACT

Results of 2 years of surveys in commercial fields and experimental carrot plots showed that a carrot weevil (*Listronotus texanus* (Stockton)) is present and feeds on carrots and dill throughout the Lower Rio Grande Valley (LRGV). Weevils move into carrot fields as early as 62 days after planting where numbers increase because of immigration and reproduction. Female weevils lay eggs in leaf petioles, larvae emerge and begin feeding in the petioles working their way down to the carrot root crown. Larvae complete development in the root and enter the soil to construct a pupal cell. Results of an evaluation of labeled and non-labeled chemicals for weevil control indicated that fenvalerate gave the best control of the tested materials.

Carrot is the fourth largest vegetable crop in the Lower Rio Grande Valley (LRGV) of Texas (1). Processing carrots occupy ca. 2000 acres and have been grown since the early 1960's. The key pest of processing carrots is a weevil, *Listronotus texanus* (Stockton), that feeds on the root as a larva and as an adult lays eggs on leaf petioles and feeds on foliage (2). Presence of larvae or feeding damage on roots can cause rejection of carrots at processing plants. Therefore, effective control measures for this pest are needed.

Effective insect control programs are built on a thorough understanding of the biology of the pest, levels of control necessary and the ability of various control measures to reduce pest numbers or minimize damage. Control programs for this weevil have consisted of 3 to 6 scheduled applications of methyl-parathion. Reports from processing plants indicated that in many years this program did not result in effective control and numerous loads of carrots were rejected. A research project was initiated in 1982 at the Texas Agricultural Experiment Station at Weslaco to develop an effective management program based on the biology of the pest and evaluation of pesticides for its control.

MATERIALS AND METHODS

Extensive surveys of LRGV carrot fields were carried out during the growing season (September to May) of 1982-83. Surveys were conducted in 60 commercial fields located throughout the LRGV by randomly selecting 100 carrots per field and examining them for larvae and larval feeding damage to leaves and roots. Research plots of carrots at the Texas Agricultural Research and Extension Center at Weslaco were surveyed throughout this same time period in a similar manner.

Commercial carrot fields were harvested by May of 1983 and surveys were shifted to weeds remaining in and adjacent to the surveyed fields in order to determine if alternate hosts for weevils existed. Common weedy species and cultivated species replanted in sample fields were surveyed periodically (10 plants/species/field). Plant species included in the surveys were: bitterweed, *Picris* spp.; sorghum, *Sorghum bicolor;* nightshade, *Solanum* spp.; sunflower, *Helianthus annuus;* pigweed, *Amaranthus retroflexus;* and dill, *Anethum graveolens*.

Intensive surveys were conducted at 2 centrally located commercial carrot fields (ca. 1 km north and south of Alamo, TX.) in the LRGV during the 1983-84 growing season. Surveys of these fields were conducted at ca. 7 day intervals from November to harvest (April). Two hundred randomly selected carrots per field were taken to the laboratory and examined under stereoscopes for eggs, larvae and feeding damage. A 1-acre (0.4 ha) plot of carrots grown at the research station was also surveyed by examining 100 randomly selected carrots at 7 day intervals from January to May.

Eggs, larvae and pupae collected from carrots and other plants surveyed during 1982-1984 were reared to adulthood and identified. Data from all surveys were summarized by sampling date.

Effectiveness of various pesticides for control of the weevil was determined in the field. 'Long Imperator 58' carrots were direct seeded into 2 row beds on 40 inch (ca. 1 m) centers at the research center on 1 April, 1985. A randomized complete block design with 5 blocks was used in this test to evaluate differences in control among 7 insecticide treatments and an untreated control plot. Plots were 4 beds wide and 20 ft (6 m) long and were treated with a tractor-mounted sprayer operated at 2 mph (3.2 km/hr), with a boom pressure of 40 psi (2.8 kg/cm^2). TX4 nozzles ca. 10 inches (25 cm) above the plant canopy were used to apply insecticides at a rate of 10 gal/acre (95 l./ha) on 1 and 14 August, and 4 and 20 September. Control plots were not sprayed. Ten carrots from the center of 2 beds of each plot were examined under stereoscopes in the laboratory on 26 July and 21 August; 20 per plot were checked on 27 September. Carrot roots and foliage were examined for eggs, larvae and larval feeding. Data were summarized and analyzed using the Waller-Duncan K-ratio t test to determine if differences among treatment means were statistically significant ($P = 0.05$).

RESULTS AND DISCUSSION

Weevil-damaged carrots were found in 35 of 60 commercial fields surveyed and live larvae were collected from 20 fields throughout Hidalgo, Willacy and Cameron counties from December 1982 to May 1983. Mean number of damaged carrots ranged from 1 to 12 per 100 carrots and mean number of larvae ranged from 0 to 5 per 100 carrots in individual fields. Approximately 2,000 plants other than carrots were surveyed for weevils and damage from 25 May to 19 September 1983 and ca. 400 weevil larvae

Table 1. Control of a carrot weevil achieved with various pesticides after 4 treatments over 8 weeks at Weslaco, Texas, 1985.

Treatment	Rate	Mean No. Per Carrot[a]				Percent[b] Control	
	lb/A	Damage	Eggs	Hatched Eggs	Larvae	Damage	Larvae
fenvalerate[c]	0.2	0.06 e	0.00 b	0.04 c	0.01 c	80.7	94.1
azinphosmethyl	0.5	0.12 de	0.04 b	0.19 abc	0.03 bc	61.3	82.4
oxamyl[c]	1.0	0.17 cde	0.23 ab	0.29 abc	0.08 abc	45.2	52.9
cyfluthrin	0.03	0.18 cde	0.05 b	0.12 bc	0.09 abc	41.9	47.1
M-parathion[c]	1.0	0.22 abcd	0.02 b	0.29 abc	0.08 abc	29.0	52.9
carbaryl[c]	2.0	0.27 abc	0.11 b	0.42 ab	0.21 a	12.9	23.5
malathion[c]	1.25	0.35 a	0.15 b	0.30 abc	0.14 abc	−6.1	17.7
untreated	--	0.31 ab	0.46 a	0.44 a	0.17 ab	0	0

[a] Means in columns followed by the same letter are not significantly different (Waller-Duncan K-ratio t test, K = 100).

[b] Percent control = (1-(treatment mean/untreated mean)) * 100.

[c] Currently labeled for carrot weevil control on carrots in Texas.

were collected from carrots and other plants. All larvae collected from carrots and dill were determined to be *L. texanus*, whereas no larvae collected from other host species were determined to be this species.

Weevil activity, as indicated by presence of larvae or feeding damage, in commercial fields surveyed during 1983-84 was first noted ca. 62 days after planting (22 November 1983). The fields surveyed were treated with methyl-parathion on six dates. Four applications were made early in the season (November-December) and the number of eggs and larvae remained low during this time. Egg, larval and damage abundance increased in late January and early February with peak egg abundance occurring on 23 February in both fields. Peak larval abundance occurred on 19 March in one field and on 6 February in the other.

Weevil activity in plots at the research center during 1983-84 was first noted on 3 January 1984. No insecticides were applied to this field and populations increased from January-March with peak egg and larval abundance occurring on 6 March.

Results indicated that peak egg, larval and damage abundance was greater in the unsprayed field than in the commercial fields that were treated with methyl-parathion. Peak percentage of plants with eggs was 21% in both of the treated fields and 78% in the untreated field. Peak percentage of plants with larvae was 21% in a treated field and 25% in the untreated field. Peak percentage damaged carrots was 20% in a treated field and 59% in the untreated field.

Results of pesticide evaluations during 1985 indicated that oxamyl (Vydate, E.I. DuPont De Nemours & Co.) and fenvalerate (Pydrin, E.I. DuPont De Nemours & Co.) were the only currently labeled materials that significantly reduced damage (Table 1). Methyl-parathion, carbaryl (Sevin XLR, Union Carbide Agricultural Products Co.) and malathion significantly reduced numbers of total eggs.

Test results also indicated that cyfluthrin (Baythroid, Mobay Chemical Co.) and azinphosmethyl (Guthion, Mobay Chemical Co.) significantly reduced damage, and numbers of hatched eggs (Table 1). These materials are not labeled for use on carrots. Fenvalerate was the only material tested that significantly reduced all variables. In terms of per cent control fenvalerate gave the greatest benefits; 80.7% reduction in damage and 94.1% reduction in number of larvae (Table 1).

Methyl-parathion has been the standard material used in control programs for *L. texanus* for the past 20 years. Unpublished reports indicate that control has been sporadic with methyl-parathion (2). The history of control failure for this pest reinforces the continued need for information concerning pest biology and the use of control techniques. In this case results indicated that pesticide applications may be delayed and concentrated towards mid- to late-season when populations begin increasing and targeted toward controlling the adult which may be more exposed to pesticides than the eggs and larvae.

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Weed Control in Seeded Cabbage, Mustard Greens, Spinach and in Transplanted Broccoli Grown Under Conservation Tillage Practices

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ABSTRACT

Preemergence applications of propachlor (Ramrod) failed to control weeds at 5.6 kg/ha but controlled all species at 11.2 kg/ha with no injury in spinach. Cabbage and mustard greens yields were reduced with 11.2 kg/ha of the herbicide, however. Metolachlor (Dual) at 1.7 kg/ha controlled all weed species but reduced the yield of spinach and mustard greens. Sethoxydim (Poast) and fluazifop-butyl (Fusilade) controlled Japanese millet but fluazifop reduced the yield of spinach. Combinations of stale seedbed applications of glyphosate (Roundup) and subsequent topical applications of bensulide (Prefar), metolachlor (Dual) or ethalfluralin (Sonalan) had no significant effect on yield of transplanted broccoli grown under conservation tillage practices.

Weed control systems have been developed for several agronomic crops including corn (3), sorghum (8), and soybean (6) grown under conservation tillage practices. Reductions in tillage with the associated higher levels of surface crop residue have reduced the populations of broadleaf weeds but allowed establishment of annual grasses and many perennial weeds (2). Little information is available on conservation tillage systems for vegetable crops. The development of efficient weed control methods within reduced tillage systems is critical for the reduction of production costs of Texas vegetables. Beste recently described the use of herbicides in tomato, beans and watermelon grown under a straw mulch (1). Majek reported that herbicides were less effective in a reduced tillage system and cabbage yields were lower (4). In 1971, Menges and Hubbard found that soil-incorporated applications of bensulide [0,0-diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl) benzenesulfonamide)] and trifluralin (2,6-dinitroN,N-dipropyl-4 (trifluoromethyl)benzenamine) were outstanding for weed control in cabbage (5). Olson and Stall reported that applications of metolachlor selectively controlled weeds in transplanted broccoli (7). Because grass weeds may escape the soil applications of many herbicides, the recent development of postemergence applications of grass weed herbicides offers great promise for broadleaf vegetable growers.

The objectives of the study were 1) to study the selectivity of new grass herbicides on cabbage, mustard greens and spinach and to determine candidate herbicides for weed control in vegetables grown under conservation tillage practices and 2) to determine the practicality of the use of topical applications of certain herbicides in transplanted broccoli grown under conservation tillage.

MATERIALS AND METHODS

nical weed control in cabbage, mustard greens and spinach. The experiment was ted on a Hidalgo sandy clay loam (52% sand, 35% clay, 12% silt) with a field y (FC) 26% H_2O, pH of 8.0, and 0.8% organic matter (OM). Soil was formed in- beds with 112 kg/ha of P, broadcasted as superphosphate, Sept. 28, 1983. On , beds were PTO-power tilled. 'Sanibel' cabbage, 'Florida Broadleaf' mustard , and 'Hybrid 7' spinach, Palmer Amaranth (*Amaranthus palmeri* S. Wats) and ese miller (*Echinochloa frumentacea* (Roxb.) Link.) were seeded. Preemergence herbicides propachlor and metolachlor were then applied, and the site was furrow ed Oct. 5. On Oct. 26, postemergence (POST) applications of herbicides were in 5 to 8 mph N winds; air temperature was 27 C, with a RH of 50%. Plant height)ST application was 7.7, 2.6, 7.9, 15.6, and 5.3 cm for cabbage, spinach, mustard s, Japanese millet and Palmer amaranth, respectively. Plots were 4 m long except in ifop plots which were 2.1 m long. On Nov. 1, the vegetables were thinned, N was dressed at 56 kg/ha, and weeds were removed. On Nov. 30, POST applications of icides were repeated at 28 C, 62% RH, and partly cloudy skies. After a hard freeze)ec. 25, dead leaves (15% of total) were removed from cabbage on Jan. 12, 1984.

rowth of broccoli with conservation tillage and herbicide applications. The eriment was conducted on a Hidalgo sandy clay loam (65% sand, 22% clay, 13% with a 1.5% OM, at 20% FC H_2O, and pH of 7.8. Cotton stalks were shredded, s were undercut and listed with a disc tiller in preparation for broccoli transplanting. Oct. 28, 1982, 'Southern Comet' broccoli was transplanted 25 cm apart in a single / on 1 m beds that were sprayed one day earlier with 2.2 kg/ha (ai) of glyphosate for ıtrol of emerged weeds in the stale seedbed. On Nov. 8, topical sprays of bensulide, tolachlor, or ethalfluralin (570 l/ha) were applied and sixty seven kg/ha N were plied as a sidedress. Plots were handweeded Dec. 14, and 21. Nudrin insecticide ıs applied at 0.26 kg/ha Nov. 29, and Dec. 1, 7, 14, 17, and 21. Rainfall at 3.8,)5, 6.9, 0.5, and 1.0 cm occurred on Nov. 2 and 27 and Dec. 9, 10, and 30, respectively. ots were furrow irrigated Oct. 19, 28, and Dec. 3, 1982. Floral stalks of plants were ırvested Jan. 18 and Feb. 4, 1983.

RESULTS AND DISCUSSION

Chemical weed control in cabbage, mustard greens and spinach. PRE applications of 1.2 kg/ha propachlor and 1.7 kg/ha metolachlor controlled all weeds (Table 1). Only millet was controlled with 5.6 kg/ha propachlor. Metolachlor stunted the growth of spinach and mustard. Sethoxydim, at 0.28 or 0.56 kg/ha, controlled millet without early injury in crops. Fluazifop controlled grass without apparent crop injury in cabbage and mustard greens but stunted the growth of spinach.

Yields were especially low in cabbage after the December 1983 freeze (Table 2). The highest yield should occur in the weeded check plots where no weed or herbicide can complete for yield. No herbicide application decreased cabbage or mustard greens yields, when its yield was compared to weeded check yield. Cabbage yield was reduced with 11.2 kg/ha of propachlor when its yield was compared with that of 5.6 kg/ha of the herbicide, however. Mustard green yields were higher with 0.28 kg/ha of sethoxydim and both application rates of fluazifop when compared to yields with 11.2 kg/ha of propachlor

Table 1. Effect of preemergence (PRE) and postemergence (POST) application of herbicides on weeds and vegetable.

Herbicide	Application method and rates (kg/ha a.i.) PRE	POST	Relative control ratings[a/] Japanese millet[b/]	Common purselane	Palmer amaranth	London rocket	Phytotoxicity Cabbage	Spinach	Mustard greens
Propachlor	5.6	5.6	98	58 b	74 b	29 b	17 ab 8[c/]	13 d	10 c
"	11.2	11.2	100	88 a	96 a	94 a	20 a 10	23 b	18 cb
Metolachlor	1.7	-	100	94 a	97 a	94 a	12 bc 9	37 a	29 a
Sethoxydim	-	0.28+0.3% crop oil	98	39 c	9 c	15 bc	9 c 7	14 cd	10 c
"		0.56+0.3% crop oil	99	38 c	8 c	14 e	12 bc 8	15 cd	12 b
Fluazifop-butyl	-	0.28+0.3% crop oil	96	37 c	14 c	16 bc	17 ac 9	26 b	11 cb
"	-	0.56+0.3% crop oil	97	35 c	11 c	16 bc	16 ac 10	21 cd	9 c
Weeded check	-	-	98	96 a	97 a	93 a	11 bc 9	10 d	9 c

[a/] Visual ratings by height and vigor 0-100 (0 = no control, 100 = complete control) averages from 4 replications. Ratings, Nov. 9, 1983, 14 days after first POST application. Means within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[b/] Ratings (Dec. 11, 1983) 12 days after second application of POST herbicides.

[c/] Phytotoxicity ratings Dec. 7, 1983, 8 days after second application of POST herbicides. All phytotoxicity ratings's 0-100 (0 = no effect, 100 = plant completely necrotic).

Table 2. Vegetable yields with preemergence (PRE) and postemergence (POST) application of herbicides.

Herbicide	Application method and rates (kg/ha)		Marketable yield[a/] (kg)		
	PRE	POST	Cabbage	Spinach	Mustard greens
Propachlor	5.6	5.6	8.2 a	8.2 a	7.0 ab
"	11.2	11.2	5.4 bc	7.3 ab	5.4 bc
Metolachlor	1.7	-	6.6 ab	7.0 b	5.2 bc
Sethoxydim	-	0.28 + 0.3% crop oil	6.4 ab	7.4 ab	7.7 a
"	-	0.54 + 0.3% crop oil	4.9 bc	7.4 ab	6.7 ab
Fluazifop-butyl	-	0.28 + 0.3% crop oil	6.6 a	4.6 c	7.6 a
"	-	0.54 + 0.3% crop oil	6.6 a	5.6 c	8.3 a
Weeded check	-	-	5.3 bc	7.0 b	7.0 ab

[a/] Averages from 4 replications. Means within a column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test. Spinach harvested Nov. 7, 1983; and cabbage Feb. 21, 1984.

Table 3. Rainfall, irrigation, and pesticide data for herbicides in cabbage, mustard greens, and spinach, 1983.

Date	Rainfall (cm)	Irrigation	Fertilizer (kg/ha)	Insecticide (kg/ha)
1983				
Sept. 28			112 P (superphosphate)	
Oct. 5		X		
12	1.8			
16	0.25			
21		X[a/]		
27				0.5 lb/A Nudrin[b/]
Nov. 1		X		56 lb/A N in H_2O
6	1.8			" "
8				" "
9	2.0			" "
16				" "
21		X		" "
29				" "
Dec. 1		X	56 lb/A N in H_2O	
15		X		" "
18-21	1.7			
1984				
Jan. 4				" "
9				" "
12				" "
Feb. 17		X	56 lb/A N in H_2O	" "

[a/] Total salt, 900 ppm.
[b/] Only cabbage was sprayed. in H_2O

and 1.7 kg/ha of metolachlor. Only fluazifop decreased spinach yields when treatment yields were compared with weeded check yields. Spinach yield was higher, however, with 5.6 kg/ha of propachlor than with 1.7 kg/ha of metolachlor.

Rainfall, irrigation and pesticide data are shown in Table 3. No rain fell soon after herbicide applications to affect activity. Several annual grass weed species can be safely controlled in broadleaf vegetables with low application rates of sethoxydim and fluazifop-butyl as shown in this study and other unreported studies here in south Texas. The use of these new grass herbicides should prevent excessive persistence of higher application rates of soil-applied herbicides. There still remains the need for broadleaf weed herbicides to complement the new grass weed herbicides in emerged vegetable crops.

Growth of broccoli with conservation tillage and herbicide applications. The combination of stale seedbed applications of 2.2 kg/ha glyphosphate and soil surface topical applications of bensulide, metolachlor or ethalfluralin had no significant effect on yield of broccoli (Table 4). Weeds were few, but there was no evidence of herbicidal injury in broccoli transplants grown under reduced tillage practices. Since it has already been established that these herbicides effectively control several weed species commonly found in broccoli, their use in broccoli transplants grown under conservation tillage practices looks promising. Had there been a larger weed population on the experimental site, broccoli yield reduction could have been demonstrated with the addition of unweeded check plots. The use of herbicide or hand-weeding effected the same yields but hand-weeding is much more expensive (unreported data).

Table 4. Yield of broccoli as affected by pretransplant (stale seedbed) and post transplant (soil-surface) herbicide applications.

Herbicide application and rate (kg/ha)			Yield[a/]	
PRE	POST		Total	Heads
			(kg)	(no)
Glyphosate 2.2	Bensulide	6.7	7.0	62
Glyphosate 2.2	Metolachlor	2.2	6.8	58
Glyphosate 2.2	Ethalfluralin	1.7	7.3	60
Weeded Check --	Weeded check	--	7.1	64

[a]Averages from 4 replications, 7.9 m. of row per plot; no statistical differences were found.

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Effect of Complete Scale Excision on Growth and Starch Accumulation in Easter Lily

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ABSTRACT

Bulb scales of Easter lily, *Lilium longiflorum* Thunb. cv. Nellie White, were completely excised during the active bulb-filling period. Scale excision caused starch level in stem and root tissues to be 4.1 and 1.2 fold, respectively, those of control plants. Dry weights of those organs were significantly higher, but only a small portion of the increased weight was accounted for by the increased starch content. Scale excision did not affect the dry weight of leaves or stem bulblets. Large numbers of starch grains accumulated in the small subepidermal and large parenchyma cells of the stem of scale-excised plants. Therefore, the stem of Easter lily can store an abundant starch if overall competition for assimilate is reduced.

Easter lily is primarily propagated by stem bulblets growing on underground nodes (3). Shoots and their attached stem bulblets are pulled out of the soil and stacked into piles shortly before the main bulbs are harvested. However, these stem bulblets continue to enlarge during piling, suggesting that some nutrients in shoots are available to bulblets. Although preliminary observations indicated that under normal conditions little or no starch grains were present in the stem during flowering, the large stem parenchyma cells would appear to have the potential to accumulate abundant starch, as do similar cells in lily leaf cuttings (9). In this study, carbohydrate supply to the remaining organs was increased by complete scale excision in order to determine the plasticity of carbon partitioning in Easter lily and the potential of the stem as a storage organ for starch.

MATERIALS AND METHODS

'Nellie White' Easter lily bulbs, 10.0 to 12.5 cm in circumference, were planted in 15-cm clay pots on 15 Oct. and grown in a cold frame. Full bloom of these plants occurred on 4 July the following year. On 11 Aug., 10 uniform plants were carefully removed from their pots so that the soil mass remained intact. Without destroying the growing points, all bulb scales on 5 plants were excised leaving only the basal plate attached to the stem. A similar amount of soil was also removed from 5 control plants to create the same amount of root damage as that on the 5 modified plants. All plants were then potted, watered, and returned to the cold frame. They were harvested after 7 weeks and separated into leaves, stem, roots, bulb and stem bulblets. Leaf area was measured with a LI-3100 area meter (LI-COR, Lincoln, Nebraska). Plants parts, including the excised scales were dried at 65 °C for 72 hr and weighed.

Leaves, stem and roots were ground in a Wiley mill to pass a 40-mesh screen and 30-mg aliquots were used for starch analysis. Soluble sugars were removed by boiling tissue samples in 8 ml of 80% ethanol for 3 min followed by centrifugation at 2800X *g* for 10 min. The supernatant was decanted and the extraction was repeated twice. The pellet was then dried, dispersed in 10 ml of 0.1 M acetate buffer (pH 4.8) containing 20 mg of amyloglucosidase (from *Rhizopus* mold, Sigma) and incubated for 90 min at 55 °C. Following centrifugation at 2800X *g* for 5 min, 0.5 ml of the supernatant was assayed for glucose using a glucose oxidase/peroxidase procedure (Sigma, No. 510). Pure potato starch was used as a standard.

A 2 mm thick section was cut from stems at 10 cm below the pedicel junction, fixed in FAA, dehydrated and embedded in paraffin. To reveal starch grains, paraffin sections were stained using the PAS method (2).

RESULTS AND DISCUSSION

During the 7-week experimental period, several replacement daughter bulbs were formed on the basal plate of scale-excised plants and accumulated a significant amount of dry weight (Table 1). However, it is not understood if these bulbs developed from the usually inactive axillary buds or from the scale tissue remaining on the basal plate.

The enlargement of stem bulblets is most active during the period between completion of anthesis and fall harvest (3, 10). Since stem bulblets can be as effective as the stem and roots as a carbon sink (10), it is surprising that the formation and weight of stem bulblets was not affected by scale excision (Table 1). Possibly the replacement bulbs prohibited the growth of stem bulblets.

Leaf area at harvest was unaffected by the treatment (Table 1) since leaf expansion had ceased about 6 weeks before scale excision. Neither total leaf dry weight nor specific leaf weight (SLW) was affected by the excision of scales, in contrast to higher SLW found in soybean (7), beans (6), wheat (1), and potato (8) as a result of removing or reducing the size of major carbon sinks. Leaves on all plants were turning yellow at harvest and had identical starch levels (Table 2). Net photosynthesis of these senescing leaves probably had decreased substantially, reducing the possibility for large amounts of assimilate to accumulate in leaves.

All vegetative growth with the exception of scale filling and root extension had been completed before scale excision was initiated. The significantly higher dry weight and starch content of the stem in response to scale excision (Tables 1 and 2)

Table 1. Leaf area and dry weights of selected organs of Easter lilies 7 weeks after bulb scale excision.

Treatment	Leaf area (cm^2)	Leaf weight (g)	Specific leaf weight (mg/cm^2)	dry weight (g)			
				Stem	Scales[z]	Stem bulblets	Root
Control	643	4.9	7.6	4.1	30.9	2.4	3.4
Scales excised	669	5.3	7.9	5.9**	4.5[y]	3.0	5.9**

[z]Weights not compared.
[y]Newly formed daughter bulbs only.
**Significantly different at 1% level.

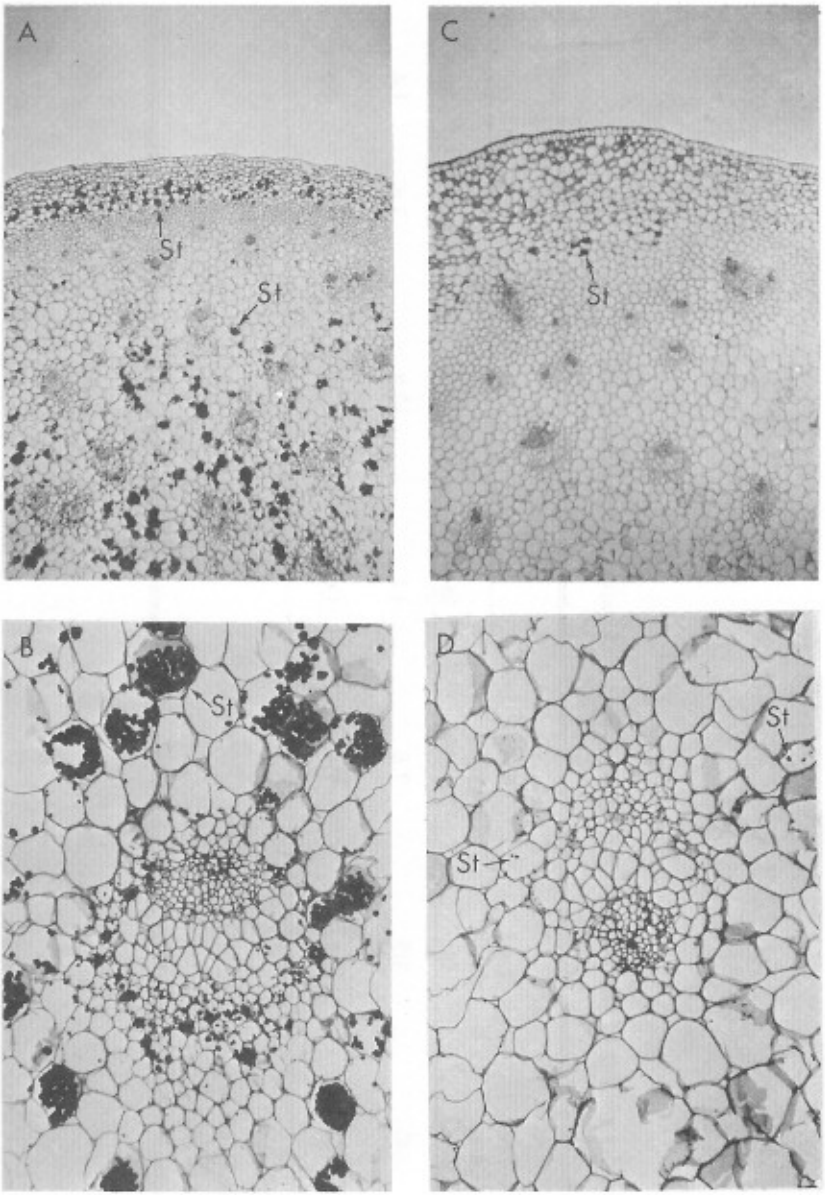

Fig. 1. Light micrographs of Easter lily stem tissues showing starch grains in subepidermal (A and C, 25X) and stem parenchyma cells (B and D, 100X) of plants from which bulb scales were excised (A and B) or left intact (C and D).

Table 2. Starch content in leaf, stem, and root of Easter lily 7 weeks after bulb scale excision.

Treatment	Starch (mg/g dry weight)		
	Leaf	Stem	Root
Control	31	18	38
Scales excised	33	73**	46**

**Significant at 1% level.

suggest that the stem can serve as an alternate sink for storing excess photoassimilates. Scale excision increased root weight through enhanced root growth and greater assimilate accumulation (Table 2). In plants with their scales excised, the increased starch contents in tissues only accounted for 20% and 6% of the increase in stem and root dry weights, respectively. The remaining dry weight may represent increases in soluble sugars (4, 5), structural materials, and other substances.

Light micrographs show that scale excision elicited large amounts of starch grains to accumulate in several layers of subepidermal cells which are some distance away from the outermost vascular bundles (Fig. 1A), and in the large stem parenchyma cells (Fig. 1B). Apparently, there was enough horizontal movement for the sugars to reach those cells capable of storing carbohydrates. The largest number of starch grains accumulated in those cells adjacent to where leaves attached to the stem (not shown). Relatively few starch grains were found in stem cells of control plants (Figs. 1C and 1D).

The study shows that parenchyma cells in Easter lily stem can be an alternate carbon sink when the major competing sinks, scales, are removed. However, it is not clear why stem bulblets failed to develop further while there was abundant starch in the stem.

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Non-research papers should be well organized, concise, and free of grammatical or typographical errors upon submission. Organization of non-research papers may depend on the information presented and should follow chronological or other logical order. Headings and subheadings may be utilized for organization. Headings should be capitalized and centered, while subheadings with the first letter capitalized should be placed at the head of the paragraph and underlined. An abstract summarizing the paper should precede the text of the paper as with research papers. Guidelines for research papers may be followed as they apply. Photographs, figures, and tables are encouraged to supplement the text.

Page charges for non-research papers are $5.00 per page. At least one author must be a member of the Rio Grande Valley Horticultural Society. Manuscripts for publication and further questions regarding submission of papers may be sent to:

Journal Editor
Rio Grande Valley Horticultural Society
P.O. Box 107
Weslaco, Texas 78596

ON THE COVER

Texas citrus makes a comeback: A cluster of 22 Ruby Red Grapefruit at the E. Hopkins Orchard near Elsa, TX. This cluster illustrates how grapefruit got its name. *Photo courtesy of Texas A&I Citrus Center.*