JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 34, 1980

ISSN 0485 - 2044

JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 34, 1980

Published by

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

Aims and Objectives of the Society

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

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

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

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

Anyone interested in horticulture can become a member of the Society. The annual 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.

TABLE OF CONTENTS

Marvin Miller
President

Officers of the Rio Grande Valley Horticultural Society 1980

PRESIDENT	Marvin Miller
PRESIDENT ELECT	Cliff Hobbs
VICE PRESIDENTS:	
Citrus	David Waddy
Vegetables	Guadalupe Saldana
Ornamentals	Rudy Roeder
Special Fruits	Jan Hruska-Mortensen
DIRECTORS:	
Citrus	Cecil Peck
Vegetables	Weldon McFarland
Ornamentals	Judy Roeder
Special Fruits	Jud Flowers
At Large	L. H. (Buck) Stover
	Jim Hearn
TREASURER	Dale Meyerdirk
SECRETARY	R. M. Davis
JOURNAL COMMITTEE:	
Editor	Robert Leyden
Associate Editors	Roger Albach
	William Carter
	Robert Rouse
NEWSLETTER	John Fucik
INSTITUTE PROGRAM COMMITTEE:	Robert Rouse, Chairman
	Jim Hearn
	Andy Hill
	Marvin Miller
	Judy Roeder
	Guadalupe Saldana

Glen G. White

Recipient of the Arthur T. Potts Award

Glen G. White, originally from Iowa, came to the Valley from Watertown, S. D. with his father, mother, and brother in 1919. His father, a farm realtor, had purchased acreage in the Valley which he planned to subdivide, retaining a portion for the family. The White's present residence on Victoria Road near Donna was part of the original purchase and has been Glen's home for over 60 years.

His agricultural career began as a hog farmer caring for some registered swine his father had purchased. After his father had returned to Iowa with his mother and brother, leaving Glen in charge of the family holdings, the young farmer disposed of the animals and went on to other pursuits.

One was the nursery business, an occupation that would engage his attention and that of his wife Neva for over 50 years. First a citrus nursery then later branching out into ornamentals. Among other achievements with ornamentals was the developing of a superior way of propagating bougainvillea and the introduction of several improved strains to this area.

Glen was a citrus and cotton farmer from the beginning. This gave him an appreciation of the importance of water to Valley agriculture. He was general manager of the first water authority in south Texas, secretary-treasurer of the Donna Irrigation District, and represented Texas Farm Bureau at the National Water Conference for two years.

As assistant sales manager of the Rio Grande Valley Citrus Exchange Juice Division, Glen helped develop new domestic and foreign markets for the rapidly expanding citrus industry of the mid 30's. The Exchange later became Texsun and Glen left an indelible mark on that organization. The Texsun logo in use today was adapted from a design by Glen. During this period he served 3 terms as president of the South Texas Canners Association.

In the early twenties Glen White was president of the Hidalgo Farm Bureau, later president of the Rio Grande Valley Farm Bureau, and eventually State Director for the Texas Farm Bureau from 1955 to 1963. He has been associated with the Rio Grande Valley Horticultural Society since its inception and served as president in 1970.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY MEMBERSHIP, 1980

SPECIAL CONTRIBUTORS

Hidalgo County Farm Bureau
Griffin and Brand, McAllen

PATRONS

American Agri-Services, Inc., Elsa
Barbee-Neuhaus Implement Co., Weslaco
Bentsen Development Co., Mission
Burton Auto Supply, Weslaco
Charlie Rankin, Voice of Valley Agricultfure, KURV, Edinburg
Crest Fruit Co., Alamo
E. I. Du Pont de Nemours and Co., Inc.
Edinburg Citrus Association
First National Bank, Mission
First National Bank, Weslaco
Langdon Barber Groves, Inc., McAllen
Metz and Kappler, Edinburg
Rio Farms, Inc., Edcouch
Rio Tex Citrus Association, Edinburg
Southland Care Co., Edinburg
Tex-Ag Company Inc., Mission
Texas Soil Laboratory, Edinburg
Texsun Corporation, Weslaco
Townsend Implement Co., McAllen
Valley Productions Care, Inc., Mission
W. T. Ellis Co., Mission
Waugh's Fruit Ranch, McAllen

SUSTAINING MEMBERS

Alamo Bank of Texas, Alamo
Bayview Orchard Service, Los Fresnos
Bickel, Herbert J., Houston
Citrus Management Corp., Mission
County Farm Nursery, Edinburg
Crockett Groves, Inc., Harlingen
Dennison's, Mid-Valley Chemical, Weslaco
Edinburg Improvement Association
ESCO, Ltd. Pharr
First State Bank and Trust Co., Edinburg
Harlingen Garden Club
Hidalgo Bank and Trust, Mercedes
Hidalgo Soil and Water Conservation District, Edinburg
K - Y Farms, Harlingen
Lily Research Laboratories, Mission
Roeder, J. K., Weslaco
Rohm & Haas Company, Houston
Sharyland Orchard and Nurseries, Inc., Mission
Stauffer Chemical Co., Weslaco
Texas Citrus Exchange, Edinburg

SUSTAINING (Cont'd.)

Tide Products Inc., Edinburg
Valley Production Credit Association, Harlingen
Walter Baxter Seed Co., Weslaco
Weaks Martin Implement Co., Inc., Mission
Williams, John L., Los Fresnos

HONORARY

Adriance, G. W., Branham
Cintron, R. H., Mercedes
Cooper, W. C., Orlando, FL
Corns, J. B., Weslaco
Correa, R. T., Weslaco
Godfrey, G., Prescott, AZ
Hill, L. C., Corpus Christi
Karcher, A. H., Edinburg
Leeper, P., Weslaco
Link, H., Weslaco
Linnard, E., McAllen
Rankin, C., Edinburg
Schulz, G. R., McAllen
Shull, A. V., Edcouch
Sleeth, G., Weslaco
White, Glen G., Donna

REGULAR

Albach, R. F., Weslaco
Amador, J., Weslaco
Anderson, N. L., San Benito
Arnall, N., Weslaco
Ausmus, W. V., McAllen
Bailey, L. L., Kingsville
Bentzinger, H. A., Edinburg
Bitters, W. P., Riverside, CA
Blakely, R. D., McAllen
Boulton, G. A., Mission
Breckenridge, C. R., Donna
Buford, W. R., Harlingen
Carter, W. W., McAllen
Caskey Estate, Weslaco
Chandler, L. D., Weslaco
Colbaugh, P. F., Dallas
Coltharp, S. L., McAllen
Connelly, C., McAllen
Conrad, J., McAllen
Cowan, D., San Benito
Cox, E., Edinburg
Crane, R. J., McAllen
Crawford, R. K., McAllen
Crocker, R. L., Dallas
Cruse, R. R., Weslaco
Davalos, G.F., Monterrey, N.L., Mexico
Davidson, C. E., Mission
Davis, R. M., Weslaco
Dean, H., Weslaco
Douglas, K., Donna
Donaldson, C. E., Weslaco
Dube, D. A., Hargill
Everitt, J. H., Weslaco
Fankhauser, D., Mission
Fankhauser, G. H., Mission
Fankhauser, H. I., Mission
Fernandez, D., Mercedes
Field, C. G., Shreveport, LA
Fitz, D. B., McAllen
Flores, A. T., McAllen
Flowers, J., Edcouch
Foerster, C. O., Elsa
Folger, D., Mission
Frazier, S., Harlingen
French, J. V., Weslaco
Fucik, J., Weslaco
Gage, E., La Feria
Gates, W. R., McAllen

REGULAR (Cont'd.)

Gausman, H. W., Weslaco
Gerbermann, A. H., Edcouch
Gibson, F., McAllen
Goff, J. M., Harlingen
Gonzalez, C. L., Weslaco
Goodier, B., Weslaco
Griffiths, F. P., Weslaco
Grossman, D., Jr., McAllen
Harding, G., Raymondville
Hart, W. G., Weslaco
Heald, C. M., Weslaco
Hearn, J., KURV, Edinburg
Henderson, S. W., Jr., Edinburg
Hensz, R. L., Harlingen
Hentz, A. E., Harlingen
Hobbs, C. D., McAllen
Hodgin, G., Mission
Honeycutt, E., Jr., Mission
Hruska-Mortensen, J. K., Weslaco
Ingle, S. J., San Benito
Jeske, D. L., Alamo
Johnson, H. S., Mission
Jones, L. F., Mission
Karle, F. G., McAllen
Kutzenburger, J., Harlingen
Leyden, R., Weslaco
Liljestrand, C. A., Edinburg
Lime, B. J., Weslaco
Longwell, D., Hargill
Louis, W. F., Richland Center, WI
Love, G. H., Weslaco
Maxwell, N., Weslaco
Meier, A. C., Mission
Menges, R., Weslaco
Meyerdirk, D., Weslaco
Murray, A. T. S., McAllen
McFarland, W., Edinburg
Nightingale, A. E., College Station
Nishuira, M., Nagasaki, Japan
Nixon, P. R., Weslaco
Orr, E. B., La Feria
Parker, W., McAllen
Peck, C., Weslaco
Peynado, A., Weslaco
Reinking, R. B., Harlingen
Rodriguez, R., New York, N. Y.
Rogers, J. L., Harlingen
Rouse, R., Weslaco
Ruby Red Grove Service, Mission
Saldana, G., McAllen
Scott, A. W., Jr., Edcouch
Sherman, D. R., Michigan
Sluis, N., Edcouch
Smiley, R., Mission
Smith, G. B., Harlingen
Smith, J., Harlingen
Smith, K., Harlingen
Smith, L., Edinburg
Snider, B. B., Harlingen
Steeno, D., Harlingen
Stein, E. R., Weslaco
Swetland, F. L., III, San Benito
Taubert, G., Harlingen
Taylor, J. L., McAllen
Texas Sweet, McAllen
Texas Valley Citrus Committee, McAllen
Theall, D., La Feria
Thode, E., Harlingen
Thompson, D., Weslaco
Villalon, B., Weslaco
Villarreal, R., Weslaco
Waddy, D., Weslaco
Wallace, C., La Feria
Wallace, D. K., Weslaco
Warren, D. G., Edinburg
Weisser, J., McAllen
Wiedenfeld, R., Weslaco
Wilhite, H., San Juan
Wright, J., Bayview
Wutscher, H., Orlando, FL

Program of the Thirty-Fourth Annual Institute
Rio Grande Valley Horticultural Society
January 22, 1980

MORNING SESSION: Dr. Rafael Cintron — Presiding

9:00 A.M.	Welcome, J. Victor French, President, Rio Grande Valley Horticultural Society.
9:10 A.M.	"Threshold Levels and Damage by Citrus Rust Mites" — Dr. Jon Allen, Entomologist, IFAS Agricultural Research and Education Center, Lake Alfred, Florida.
10:10 A.M.	Juice and Donut Break
	A symposium - Integrated Pest Management
10:30 A.M.	"Biocontrol of Citrus Mealybug" — Dale Meyerdirk, Entomologist, Citrus Insects Lab., U.S.D.A./A.R., Weslaco, Texas
10:45 A.M.	"Inter-Relation of Chemical and Biological Control" — H. A. Dean, Entomologist, T.A.E.S., Weslaco, Texas
11:00 A.M.	"Development of Extension Demonstration Work and Scouting Techniques for Citrus Rust Mites" — Leon Smith, Citrus IPM Co-ordinator, County Agent - Citrus
11:15 A.M.	IMP Panel Questions and Answers
11:30 A.M.	PRESENTATION OF ARTHUR T. POTTS AWARD Victor French, President of the Society
11:45 A.M.	ELECTION OF OFFICERS AND OTHER SOCIETY BUSINESS - Victor French

AFTERNOON SESSION: Mr. Charlie Rankin — Presiding

1:15 P.M.	"Vegetable Industry in the Soviety Union" — Othal Brand, Mayor of McAllen and Chairman of Board of Directors of Griffin and Brand of McAllen, Inc.
2:00 P.M.	"Fertilization of Vegetables in the Rio Grande Valley" — Bob Wiedenfeld, Soil Scientist, T.A.E.S., Weslaco, Texas
2:20 P.M.	"Pest Detection and New Pest Detection - Ref. Citrus and Vegetables" — Jimmy L. Lockler, U.S.D.A. - APHIS - PPG Officer
2:40 P.M.	Juice Break
3:00 P.M.	"Marketing of Texas Grapefruit Juice" — Jay Holford, TCX, President
3:20 P.M.	"Future of Alcohol as an Energy Source" — John Hutcheson, Energy Advisor to the Commissioner of Agriculture
3:40 P.M.	Adjourn

EVENING SESSION: Dr. Cliff Hobbs — Presiding

7:30 P.M.	"Low Light Plants for House and Garden" — Mrs. G. Browning Smith, Horticulture Instructor, National Federation of Garden Clubs
8:00 P.M.	"Insect Control on Ornamentals" — Larry Chandler, Entomologist, T.A.E.S. in cooperation with U.S.D.A. Subtropical Fruit and Vegetable Research, Weslaco, Texas
8:30 P.M.	"Disease Control on Ornamentals" — Phillip Colbaugh, Ornamental Plant Pathologist, T.A.E.S., Dallas, Texas

Guidelines for Authors

Submit two copies of manuscripts doubled-spaced, including tables, figures, table headings, and figure captions. All margins must be at least one inch. The last word at the bottom of each page must be complete.

Subjects: Previously unpublished scientific research and observations, review and technique articles, reports of new problems or pests, market evaluations, variety releases, etc., are acceptable for publication. Papers should pertain to Lower Rio Grande Valley's horticulture. Pertinent research which has been conducted elsewhere is acceptable. Manuscripts dealing with non-horticultural crops are acceptable if some application to horticultural science exists. Popularized or new versions of previously published information are unacceptable.

Title: Keep title brief, but let it reflect important aspects of the article. Capitalize only the first letter of important words.

Byline: Author's name follows the title, followed by author's affiliation (title and institution) and institutional address with zip code.

Additional index words: This heading with a list of additional key words not used in the title may follow the byline.

Abstract: An author-written abstract follows the index words separated with space. The abstract should be brief, concise, and informative. Do not exceed 5% of the length of the paper. Separate the abstract from the text with a solid line, use two to four spaces above and below the line.

Text: An "Introduction" heading is not used. Introductory statements should give the background and objectives of the research work reported, or purpose of the article. Use no footnotes, supplementary information should be included in the text and may be parenthesized.

The body of a research paper should be divided into sections such as MATERIALS AND METHODS, RESULTS, DISCUSSION, followed by ACKNOWLEDGEMENTS and LITERATURE CITED, or other appropriate headings. Subheadings with the first letter capitalized may be placed at the beginning of paragraphs and underlined.

Names of proprietary substances, materials, and special apparatuses should be followed by parenthesized names and addresses of the manufacturers.

Chemicals, fungicides, insecticides, herbicides, etc., should be listed by their approved common names. The chemical name should be parenthesized following the common name when it is first used in the text. Use the chemical name when the common name is not available. Use trade names only if no other name is available.

Tables and Figures: Indicate in the manuscript's margin where each table and figure should appear. Captions and headings should describe figures and tables so that they are understandable when considered apart from the text.

Each table should be typed on a separate page without crowding its columns.

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

Enumeration and Measurements: Use numerals whenever a number is followed by a standard unit of measurement ; e.g., 2 g or 9 days, otherwise use words through nine and numerals for numbers larger than nine.

You may select either the metric or English system of measurements, but do not interchange them. However, equivalent measures of the non-selected system may be parenthesized; e.g., 908 g/500 liters (1.52 lb/100 gal).

When in doubt as to manuscript preparation or literature citation style, please consider that we attempt to follow the style of the Journal of the American Society for Horticultural Science where this does not conflict with specific guidelines mentioned above.

All manuscripts are reviewed by the editor and an associate editor who may seek additional review by appropriate specialists. Acceptance of a manuscript may depend on some revision following review. Final decision on acceptance is made by the editor.

One author of the paper must be a member of the Rio Grande Valley Horticultural Society. There will be a page charge of $15.00 per printed page in the *Journal.*

Manuscripts for publication in the *Journal*, if mailed, should be sent to:

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

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Yield Loss Effects of the Citrus Rust Mite[1]

J. C. Allen
University of Florida, IFAS
Agricultural Research and Education Center
P. O. Box 1088
Lake Alfred, Florida 33850

ABSTRACT

Loss in volume from citrus rust mite damage occur from increased fruit drop and decreased fruit size for damaged fruit. Since fruit drop is cumulative, longer times between damage and harvest produce greater losses. Thus, early damage and late harvest tend to produce the greatest losses. Calculations based on our data indicate that groves with 10% of the fruit surface damaged will experience 2.4 to 4.8% volume loss. Groves with 20% surface area damaged will show a 5.0 to 9.8% volume loss and groves with 30% surface area damaged will show a volume loss of 8.0 to 15.3%.

The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), is a longstanding and widespread pest of Florida citrus (6). Rust mite has been implicated in size loss in Florida (10), but the data is only correlational in nature. In addition, yield losses have been noted (7, 8), but these losses are confounded with the effects of other pest species. It is my purpose to summarize results of Florida studies on the relationship between rust mite damage and loss of volume in citrus.

The Relationship Between Rust Mite Population and Surface Damage.

Field studies (1) have shown that it is not adequate to simply consider the mite population level. One must also consider the time for which the mites have been present on the fruit. The best way we have found for doing this is to use "mite-days" as the predictor of percent of surface area damaged in a grove. A mite-day is defined as one mite feeding on one cm^2 for one day and damage accumulates directly with mite-days (Fig. 1). In calculating percent surface damaged from mite-days one must allow for an increasing fruit sensitivity to damage with age of the fruit. Late-season fruit (December) are 5 to 10 times more sensitive to mite-days than early-season fruit (June). Mite-days can be calculated by calculating the area under a mite population graph and accumulating the results as cumulative mite-days for a grove.

---

[1] Presented at the Thirty-fourth Annual Institute of the Rio Grande Valley Horticultural Society, Weslaco, Texas, 22 January 1980.

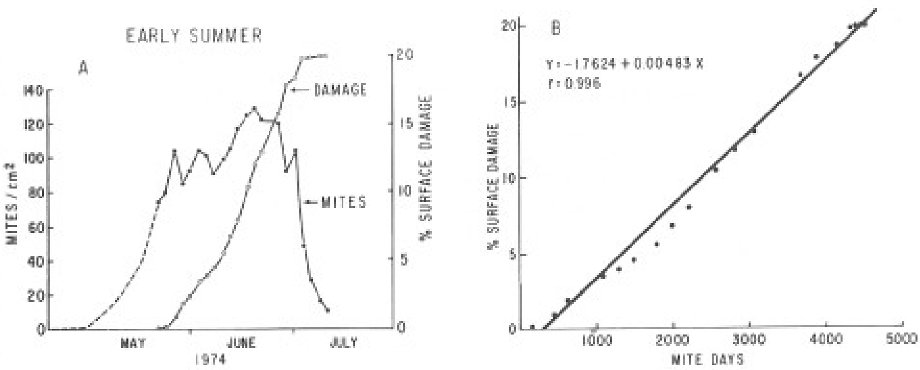

Fig. 1. Relationship between rust mite population density and percent surface area damaged on 'Valencia' orange in early summer (A) and linear relation between mite days and damage (B).

The Relationship Between Rust Mite Damage and Fruit Growth.

Early authors have noted negative relationships between rust mite damage and fruit size (10). More recently, work in Japan (9), and in Florida (3) has confirmed the earlier study. More importantly however, the recent work goes one step further to show that not only is there a negative size relationship at harvest, but that damaged fruit have a slower growth rate. That is, a fruit will grow more slowly if it has rust mite damage, and the end result is a smaller fruit at harvest (Fig. 2).

In addition to the size effects of rust mite damage, we have noted slight increases in soluble solids and acid for damaged fruit with negligible change in the solids/acid ratio. The increase in solids is on the order of 1%, and therefore this gain does not offset the volume loss from size reduction which is typically 25%.

The Relationship Between Rust Mite Damage and Fruit Drop.

Measurements of water loss from on-tree 'Valencia' oranges have indicated higher water loss from damaged fruit than from normal fruit. This suggested that rust mite damage could increase the tendency for a fruit to drop off the tree. Pull testing indicated that damaged fruit were not bound as tightly to the tree as normal fruit, and this led us to conduct four separate drop tests. In 2 'Valencia' orange tests, 1 'Pineapple' orange test and 1 'Marsh' grapefruit test, damaged fruit were observed to drop faster than undamaged fruit (2,4) (Fig. 3).

In addition, it was found that the drop rate was temperature dependent, and a degree-day time scale was helpful in reducing variation. Various water-related variables such as rainfall, humidity and vapor-pressure deficit were examined by regression techniques, but they were found to add very little additional information over and above that provided by temperature and rust mite damage.

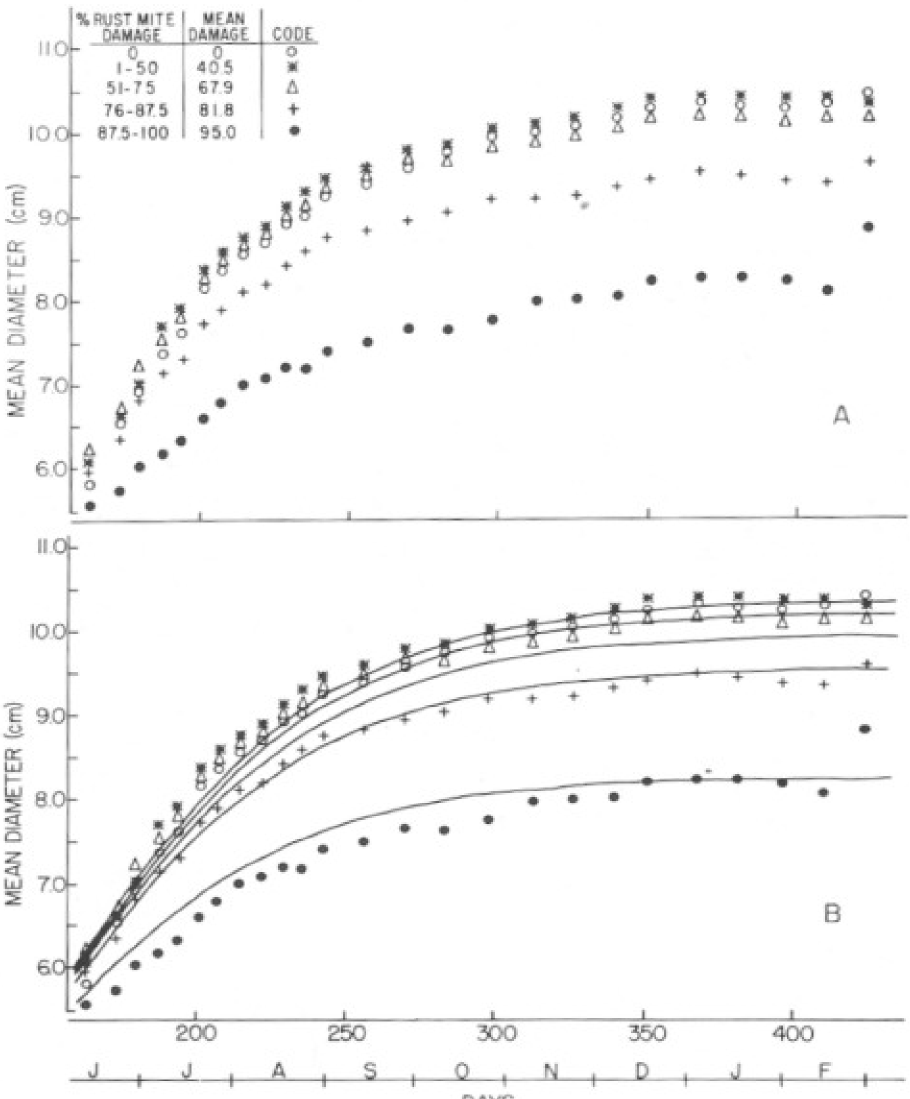

Fig. 2. Transverse diameter growth of 'Duncan' grapefruit with different amounts of percent surface damage by citrus rust mite (A) raw data (B) data compared with a growth model (Allen 1979a).

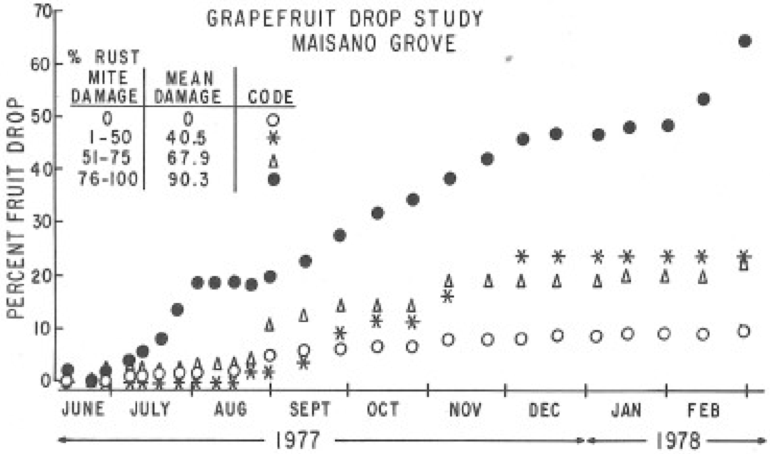

Fig. 3. Cumulative percent fruit drop for 'Duncan' grapefruit with different amounts of rust mite damage.

Putting It All Together.

How can we extend the effects of drop and size loss to a whole grove? The information obtained allowed us to quantify the effects of damage on volume loss for specific amounts (percent surface area) of rust mite damage. But we must also know the relative frequency of fruit in different damage classes, i.e., the frequency distribution of damage classes. This frequency distribution has been found to be a modified 'beta' distribution which can be completely determined from the mean percent surface damage (5). Multiplying the loss function for drop or size by the frequency distribution produces a 'weighted' loss function. Loss (e.g. drop) is then added up from this weighted function over all percent damage giving the total percent loss in the grove. Starting and ending dates, the temperature and the mean percent damage in the grove are the only things which must be known. From this information, percent volume loss for the specified conditions can be calculated. The computer program which does these calculations has been named the Citrus Rust Mite Game (CRM GAME).

Calculations indicate that for a grove with 10% surface area damaged volume loss runs from about 2.4 to 4.8%; with 20% surface area damaged from 5.0 to 9.8%; and with 30% surface damaged from 7.9 to 15.3% (Table 1). Volume loss can be interpreted in terms of dollars if we know the value per unit of volume (e.g. dollars per box). This will vary considerably from grove to grove and season to season, thus no single 'economic threshold' of damage exists. We can only say that a particular amount of damage produces a dollar loss in a given situation which equals the cost of a spray. The cost of a supplemental miticide in Florida has been estimated to be about $25/ac (ca. $62./ha). When this cost is compared to its equivalent amount of rust mite damage for different crop values, it is found that the damage equivalent to a spray runs from roughly 10 to 20% of the surface area of the fruit (Fig. 4). Variations in this amount will, of course, be subject to timing and crop value, and more exact calculations require specific inputs for the particular situation.

LITERATURE CITED

1. Allen, J. C. 1976. A model for predicting citrus rust mite damage on 'Valencia' orange fruit. Environ. Entomol. 5:1083-1088.
2. ________ 1978. The effect of citrus rust mite damage on citrus fruit drop. J. Econ. Entomol. 71:746-750.
3. ________ 1979a. Effect of citrus rust mite damage on citrus fruit growth. J. Econ. Entomol. 72:195-201.
4. ________ 1979b. The effect of citrus rust mite damage on fruit drop in three citrus varieties. Proc. Fla. State Hort. Soc. 92:46-48.
5. ________ and J. H. Stamper. 1979. Frequency distribution of citrus rust mite damage on citrus fruit. J. Econ. Entomol. 72:327-330.
6. Hubbard, H. B. 1885. Insects affecting the orange. USDA, Div. Entomol. Special Rept. 1885. 227 pp.
7. McCoy, C. W., R. F. Brooks, J. C. Allen and A. G. Selhime. 1976. Management of arthropod pests and plant diseases in citrus agroecosystems. Proc. Tall Timbers Conf. Ecol. Anim. Control by Habitat Manag. 6:1-17.
8. Osburn, M. R. 1942. Cost of control measures for the rust mite. Citrus Ind. Mag., Sept. p. 3, 7, 11.

Table 1. Percent loss predicted for a citrus grove with various amounts of initial surface area damaged by citrus rust mite.

Time of damage		Time of harvest 11/01/78	01/01/79	03/01/79	05/01/79
		10% Initial surface area damaged			
06/01/78	vol.[z]	3.44	3.91	4.36	4.79
	s.s.[y]	2.42	2.91	3.38	3.84
08/01/78	vol.	2.95	3.43	3.90	4.35
	s.s.	1.90	2.41	2.90	3.37
10/01/78	vol.	2.44	2.95	3.43	3.89
	s.s.	1.38	1.90	2.41	2.90
12/01/78	vol.	--	2.44	2.94	3.42
	s.s.	--	1.37	1.90	2.40
		20% Initial surface area damaged			
06/01/78	vol.	7.10	8.05	8.96	9.84
	s.s.	5.05	6.03	6.96	7.87
08/01/78	vol.	6.09	7.08	8.02	8.94
	s.s.	4.01	5.03	6.00	6.94
10/01/78	vol.	5.06	6.09	7.07	8.02
	s.s.	2.96	4.01	5.02	6.00
12/01/78	vol.	--	5.05	6.08	7.06
	s.s	--	2.95	4.00	5.01
		30% Initial surface area damaged			
06/01/78	vol.	11.12	12.57	13.96	15.29
	s.s.	8.03	9.48	10.87	12.22
08/01/78	vol.	9.57	11.09	12.53	13.92
	s.s.	6.48	7.99	9.44	10.84
10/01/78	vol.	7.98	9.57	11.08	12.53
	s.s.	4.90	6.47	7.98	9.44
12/01/78	vol.	--	7.97	9.55	11.06
	s.s.	--	4.89	6.46	7.97

[z] Total volume loss.

[y] Soluble solids loss, taking account of volume loss and an increase in dissolved solids concentration in damaged fruit.

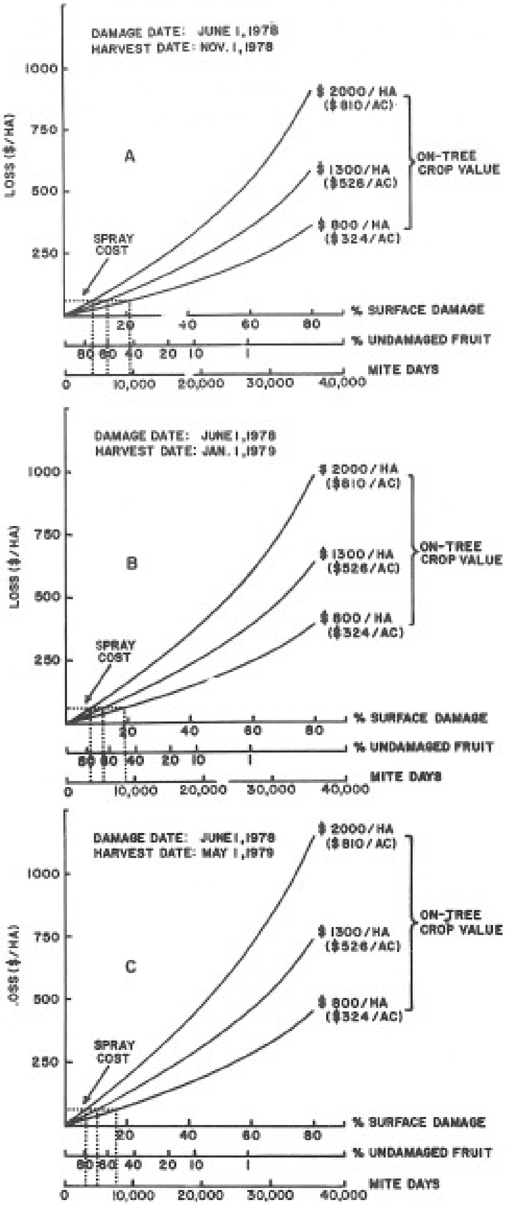

Fig. 4. Estimated dollar loss for different on-tree crop values as a function of % surface damage, % undamaged fruit ("Pack-out") or mite days. Damage occurs on June 1 and harvest occurs on (A) Nov. 1, (B) Jan. 1 or (C) May 1.

9. Tono, T., S. Fujita and S. Yamaguchi. 1978. Effect of inestation by citrus rust mites, *Aculus pelekassi* Keifer, on development of 'Satsuma' mandarin fruit and availability for juice processing from damaged fruit. Agric. Bull. Saga Univ. 44:57-66.
10. Yothers, W. W. 1918. Some reasons for spraying to control insect and mite enemies of citrus trees in Florida. USDA Bull. 645. 19 pp.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Processing Characteristics of The Star Ruby Grapefruit

Robert R. Cruse and Bruce J. Lime
Research Chemist and Retired Supervisory Research Chemist, respectively
Food Crops Utilization Research
AR, SEA, USDA, Weslaco, TX 78596

ABSTRACT

The Star Ruby grapefruit showed 8.8° - 9.7° Brix, 1.05 - 1.45% acid, and lower brix/acid ratio than the Ruby Red grapefruit. Vitamin C and naringin were in about the same range throughout the season. Incorporation of 30% - 40% Star Ruby juice in blends with Ruby Red juice should give an adequate depth of pinkness in processed juice. Storage qualities are acceptable.

The Star Ruby grapefruit (*Citrus paradisi* Macf.), developed at Texas A&I University Citrus Center, Weslaco, Texas, is a seedless, dark-red fleshed grapefruit originating from irradiated 'Hudson' grapefruit seed (1). Until recently, the major maturity and processing characteristics of the variety could not be determined because of insufficient fruit. With the release of the budwood in 1970 (1) fruit has become available to give an adequate indication of the internal quality of the juice and the approximate length of the maturity season. The objective of this investigation was to obtain and organize these data.

The grapefruit industry in Texas is based primarily on pink grapefruit. They have a thinner rind than most of the white varieties and a well-accepted flavor. Fresh market preference for the seedless pink grapefruit has essentially forced the processing industry to use these fruit, since little else is available. Since the Ruby Red fruit fades significantly with advancing maturity, the Star Ruby, with its darker pigmentation, was considered to offer the potential of maintaining a desirable color level in canned Ruby Red juice.

MATERIALS AND METHODS

Field run fruit of Ruby Red and Star Ruby varieties was obtained by arrangement with the Texas A&I University Citrus Center. Samples were taken early in the season (first or second week in December), in midseason (about the third or last week in January) and late in the season (about the middle of March). Samples were gathered over three harvest seasons from 1974 to 1977.

The fruits were washed on a set of brush rolls and the juice extracted in an FMC Model 091B In-line Test Extractor fitted with 0.025" screens. Ruby Red juice containing 0%, 10%, 20%, and 30% Star Ruby juice were canned hot in 6-oz cans. In the mid-, and late-season packs a blend containing 40% Star Ruby juice was included.

Brix was determined on a B. and L. "Abbe-3L" refractometer and corrected for temperature. Acids were titrated with standard NaOH solution to pH 8.2 and reported as percent anhydrous citric acid. Pulp content was determined using 50 ml of well-agitated juice in a 50 ml conical centrifuge and centrifuging at 1300 rpm for 10 min; the reading on the tube was doubled and reported as percent pulp. Naringin content (ppm) was determined by the Davis test (5). Vitamin C, reported as milligram percent L-ascorbic acid, was assayed by the colorimetric procedure of Nelson and Somers (6).

The canned blends were organoleptically evaluated at quarterly intervals according to the 9-point Hedonic Scale of Peryam (7). A panel of nine laboratory personnel, all familiar with the flavor of grapefruit juice throughout the season, was generally utilized.

RESULTS AND DISCUSSION

The brix/acid ratio as well as the brix content of the Star Ruby was generally less than that of the Ruby Red in every sampling except the last two of 1977, when the brix was in the same range (Table 1). Acid content varied, but appeared to be lower in the Star Ruby. Pulp content was generally lower in Star Ruby juice and was attributed to thicker-walled juice sacs (more pulp from the juice sacs of the Star Ruby than of the Ruby Red in the interior pulp exit the FMC extractor). This may account for the variations observed. Also, in visual laboratory observations, we noted that Star Ruby had coarser, firmer interior texture than Ruby Red. Seasonal variations from 31 to 43 mg% in Vitamin C content of Ruby Red grapefruit have been reported (8), and we found that naringin also varied. In the 1976-77 season, the naringin increased from 110-120 ppm to 316-356 ppm in midseason to 595-645 ppm in late season. This may be associated with an extended rainfall from Dec. 15, 1976 to about Feb. 2, 1977 as the trend was not noted the other two seasons. The differences between Ruby Red and Star Ruby in Vitamin C and naringin content were not significant since contents of the blends did not consistently reflect those of the straight juices within any given harvest period, most likely due to sampling variations.

The flavors of straight juices and blends remained acceptable (5 or higher in taste evaluations) over a 1-year storage period at ambient temperatures (60° - 96° F) (Table 2). A shorter storage time would be preferable (e.g., 6 months).

Two sets of yield data indicated that the Star Ruby fruit contained about 5% less juice (thru 0.025" screens; other conditions of extraction identical) than the Ruby Red. This would appear to have been due to the generally smaller observed size of the Star Ruby fruit in the samples received, as well as to genetic characteristics such as thicker juice sacs. Representatives of the local Texas citrus processing industry indicate a level of 20-30% Star Ruby in a blend at the beginning of the harvesting season and 40% at the end would maintain a desirable color level. (9)

Table 1. Maturity Data for Ruby Red and Star Ruby Juice and Their Blends.

	Sample	Brix	Acid %	Brix/Acid Ratio	pH	% Pulp	Vit. C mg%	Naringin ppm
12/11/74	Ruby Red	10.2	1.37	7.4	3.1	11	28	160
	10% Star	10.0	1.33	7.5	3.1	8	26	160
	20	10.0	1.32	7.6	3.1	9	26	150
	30	9.7	1.26	7.7	3.1	6	26	150
	Star Ruby	9.3	1.11	8.4	3.2	5	26	130
1/21/75	Ruby Red	9.5	1.04	9.1	3.0	10	34	130
	10% Star	9.5	1.04	9.1	3.1	12	34	135
	20	9.6	1.04	9.2	3.0	10	34	135
	30	9.4	1.05	9.0	3.1	9	36	135
	40	9.4	1.04	9.0	3.3	10	36	135
	Star Ruby	9.1	1.05	8.7	3.3	11	32	140
3/18/75	Ruby Red	11.2	1.19	9.4	3.5	16	32	155
	10% Star	11.1	1.21	9.2	3.4	14	34	155
	20	10.9	1.19	9.2	3.4	13	34	155
	30	10.8	1.22	8.9	3.4	12	32	155
	40	10.9	1.25	8.7	3.4	12	28	155
	Star Ruby	9.7	1.25	7.8	3.4	12	24	135
12/8/75	Ruby Red	10.5	1.45	7.2	2.9	12	25	120
	10% Star	10.8	1.43	7.6	2.9	12	36	135
	20	10.4	1.40	7.4	2.9	12	32	130
	30	10.4	1.38	7.6	2.9	12	30	135
	Star Ruby	9.7	1.26	7.7	3.4	12	36	135
1/26/76	Ruby Red	10.4	1.18	8.8	3.5	7	36	95
	10% Star	10.0	1.16	8.6	3.5	8	30	140
	20	10.0	1.17	8.5	3.5	8	30	95
	30	9.9	1.18	8.4	3.5	7	30	90
	40	10.1	1.20	8.4	3.5	8	30	120
	Star Ruby	9.4	1.19	7.9	3.5	8	20	90
3/25/76	Ruby Red	10.1	1.16	8.7	3.2	11	48	120
	10% Star	9.9	1.15	8.6	3.2	11	48	110
	20	9.7	1.14	8.5	3.3	10	46	95
	30	9.6	1.13	8.5	3.3	9	46	95
	40	9.4	1.12	8.4	3.3	9	46	95
	Star Ruby	8.8	1.06	8.3	3.4	5	38	90
12/14/76	Ruby Red	9.4	1.45	6.48	3.1	6	24	120
	10% Star	9.3	1.46	6.37	3.1	8	24	120
	20	9.2	1.44	6.39	3.0	7	28	120
	30	9.3	1.46	6.37	3.1	7	28	115
	Star Ruby	8.8	1.45	6.07	3.5	6	22	110
2/22/77	Ruby Red	9.1	1.35	6.7	3.1	11	28	342
	10% Star	9.8	1.39	7.1	3.1	11	26	342
	20	9.6	1.38	7.0	3.2	12	26	356
	30	9.6	1.39	6.9	3.2	14	22	330
	40	9.6	1.38	7.0	3.2	12	22	316
	Star Ruby	9.7	1.38	7.0	3.2	10	20	
3/23/77	Ruby Red	9.6	1.24	7.7	3.3	8	38	620
	10% Star	9.3	1.24	7.5	3.3	11	38	607
	20	9.1	1.26	7.2	3.25	11	32	607
	30	9.1	1.29	7.0	3.2	11	32	595
	40	9.3	1.20	7.8	3.2	11	28	595
	Star Ruby	9.3	1.20	7.8	3.3	12	26	645

Table 2. Taste Tests of Ruby Red & Star Ruby Juice, and their Blends [a]

	Sample	Ratings (Average) After months 3	6	9	12
12/11/74	Ruby Red	6.6	6.1	6.6	6.3
	10% Star	6.0	6.3	6.5	6.4
	20	6.6	6.4	6.4	5.7
	30	6.5	6.5	6.8	6.2
	Star Ruby	6.3	6.4	6.8	6.0
	LSD 0.05	NS	NS	NS	NS
1/29/75	Ruby Red	6.7	7.0	6.5	6.1
	10% Star	6.5	6.6	6.1	6.2
	20	6.3	6.8	6.8	6.1
	30	6.1	7.1	6.4	6.2
	40	6.3	6.7	6.6	6.4
	Star Ruby	6.2	6.0	6.2	5.8
	LSD 0.05	NS	NS	NS	NS
3/18/75	Ruby Red	6.7	6.2	6.4	5.8
	10% Star	7.5	6.2	6.2	6.2
	20	7.1	6.6	6.8	5.5
	30	7.1	6.6	7.1	5.8
	40	7.5	6.2	6.7	6.7
	Star Ruby	7.1	6.4	6.7	5.3
	LSD 0.05	NS	NS	NS	0.65
12/1/75	Ruby Red	5.6	3.6	5.1	5.2
	10% Star	6.2	3.8	5.6	6.3
	20	6.3	4.3	5.5	6.2
	30	5.8	4.7	5.5	5.8
	Star Ruby	6.3	4.6	5.5	6.4
	LSD 0.05	NS	NS	0.29	0.67
1/26/76	Ruby Red	7.0	6.7		5.7
	10% Star	6.2	4.7		6.5
	20	7.0	6.3		5.5
	30	7.0	5.6		6.1
	40	7.3	6.2		5.5
	Star Ruby	7.3	6.0		5.3
	LSD 0.05	0.70	0.99		NS
3/24/76	Ruby Red	5.0	5.7		4.0
	10% Star	6.2	5.7		5.1
	20	6.4	6.3		6.0
	30	6.4	5.8		6.1
	40	6.2	5.6		6.6
	Star Ruby	6.2	4.1		6.6
	LSD 0.05	0.67	0.67		0.84
12/14/76	Ruby Red	5.4	5.1	3.7	5.1
	10% Star	5.0	4.6	4.1	5.2
	20	5.4	5.7	4.0	5.0
	30	5.5	5.8	4.4	4.5
	Star Ruby	6.0	4.8	4.4	5.1
	LSD 0.05	0.67	0.88	NS	NS
2/22/77	Ruby Red	5.6	5.4	5.7	4.1
	10% Star	6.0	4.8	4.7	5.4
	20	6.0	5.8	5.3	4.7
	30	6.0	5.5	5.2	4.7
	40	6.2	5.7	5.6	4.3
	Star Ruby	6.1	5.7	5.0	4.6
	LSD 0.05	NS	NS	0.73	NS
3/23/77	Ruby Red	5.3	5.4	5.0	4.8
	10% Star	5.6	5.7	5.1	4.7
	2/	5.8	5.5	5.1	4.7
	30	6.6	5.5	4.8	5.1
	40	6.3	5.6	5.3	5.1
	Star Ruby	6.3	5.6	5.1	4.7
	LSD 0.05	0.99	NS	NS	NS

[a] Rating system: Scale of 1 to 9 with 1= dislike extremely; 5= neither like nor dislike; and 9= like extremely. Ratings ≥ 5.0 are satisfactory.

LITERATURE CITED

1. Hensz, R. H. 1971. Star Ruby, a new deep-red fleshed grapefruit variety with distinct tree characteristics. J. Rio Grande Valley Hort. Soc. 25:54-58.
2. Lime, B. J., T. S. Stephens, and F. P. Griffiths. 1954. Processing characteristics of colored Texas grapefruit. I. Color and maturity studies of Ruby Red grapefruit. Food Technology 8:(12) 566-569.
3. _______ ., T. S. Stephens and F. P. Griffiths. 1956. Processing characteristics of colored Texas grapefruit. II. Correlation of color measurements and pigment analysis of Ruby Red grapefruit. J. Rio Grande Valley Hort. Soc. 10:53-63.
4. _______ ., T. S. Stephens, A. E. Purcell, and F. P. Griffiths. 1959. Pigmentation, pigment analyses, and processing of colored grapefruit. J. Rio Grande Valley Hort. Soc. 13:30-38.
5. Davis, W. H. 1947. Determination of flavonones in citrus fruits. Anal. Chem. 19:476-478.
6. Nelson, W. L., and G. F. Somers. 1945. The determination of ascorbic acid. Ind. Eng. Chem. Anal. Ed. 17:(12) 754.
7. Peryam, D. R. 1964. Sensory testing at the Quartermaster Food and Container Institute. Lab. Pract. 13:(7).
8. Cruse, Robert R. and B. J. Lime. 1977. Content and seasonal variation of L-ascorbic acid in Texas Ruby Red grapefruit. J. Rio Grande Valley Hort. Soc. 31:53-58.
9. ___________ ., B. J. Lime and R. A. Hensz. 1979. Pigmentation and color comparison of Ruby Red and Star Ruby grapefruit juice. J. Agric. Food Chem. 27:641.

Oil Content and Fatty Acid Composition of Spring and Summer Planted Sunflowers

Eduardo R. Stein, Marvin D. Heilman and Amelia T. Murray
Research Chemist, Soil Scientist and Chemist, respectively
Subtropical Texas Area, Southern Region, SEA, USDA,
Weslaco, TX 78596

ABSTRACT

The content of oil, fatty acid composition, protein content, and seed dry weight were determined for seeds collected from sunflowers (*Helianthus annuus* L. cv. Sunbred 212 hybrid) at different stages of maturity from spring and summer plantings. For each planting season, seed weight and oil content approached a maximum 28 days after petal drop. Protein content of the seed was not significantly different between spring and summer plantings. Oil in seeds harvested from spring plantings contained more oleic than linoleic acid at all harvest dates except at 7 days after petal drop, but the converse was true of oil in seeds from the summer plantings. Sunflower seeds approached physiological maturity 28 days after petal drop.

The sunflower has very rapidly established itself as an excellent oilseed crop in the northern plains of Texas. In the Lower Rio Grande Valley of Texas the sunflower has the potential of becoming a competitive short season crop provided plant pests and diseases can be controlled or eliminated (4, 5).

Physiological maturity of the sunflower head is defined as the point at which the size of the seed and its oil and triglyceride contents are maximum (1, 12). A visual characteristic that has been associated with head and seed maturity is color: the back of the head is yellow rather than green and the bracts are black (6).

Studies of mature sunflower heads indicate variations in the oil content of the seeds among heads and within heads (3). These investigators also found significant differences in the fatty acid composition of the oil from the seeds located in different positions within the head (14).

The fatty acid composition of the sunflower seed oil is observed to vary with location and climatic conditions during the growing season (11). These observations indicate complex factors that contribute to the lack of uniformity in seed development within the sunflower head. Therefore evaluation of the sunflower as an economical oil seed crop must include data on physiological maturity.

This study was undertaken to determine the oil and fatty acid composition at intervals after petal drop in the seed of the hybrid Sunbred 212 sunflower which was selected for its high yields and uniformity and earliness of bloom (4).

MATERIALS AND METHODS

Sunbred 212 hybrid seeds were planted in the spring and summer of 1976 in a completely randomized block design with four replications at the Soil and Water Conservation Research Farm in Weslaco, Texas. The soil is a Hidalgo fine sandy loam. The heads were marked and hand harvested at random at 7, 14, 21, and 28 days thereafter. The seeds were removed by hand, and only those with a black hull were mixed for sampling. Seeds from 3 to 5 heads from each harvest date were used. The seeds were washed with a 1% sodium hypochlorite solution, rinsed with distilled water and dried in a 60°C oven to a 9 to 11% moisture level.

Moisture and oil content of the seeds were determined according to the method of Robertson (9).

Nitrogen was determined by the Kjeldahl method according to the Official Methods of the A.O.A.C. (7) and the analyses were performed by Pan American Laboratories, Brownsville, Texas. Protein was calculated by multiplying the Kjeldahl N by 6.10.

The fatty acid composition of the oils was determined by the transesterification of the glycerides in the oil with a methanolic-base reagent (13). The mixture of fatty acid methyl esters was separated on a 3m x 3.2mm o.d. stainless steel coiled column packed with 12% EGS on 8/100 mesh Chrom W. A Perkin-Elmer Model 900 gas chromatograph equipped with a flame ionization detector was used for the analyses. For quantitation the area under each fatty acid methyl ester peak in the chromatograms was determined with a planimeter.

RESULTS AND DISCUSSION

The percent oil, on a dry weight basis, for each harvest date is shown in Figure 1. The interval between loss of petals and physiological maturity as determined on the basis of maximum oil content may be greater than 28 days because the oil content of the seeds was still increasing on 28th day.

At petal drop the back of the sunflower head was no longer green but yellow. This color change which has been reported to be associated with seed maturity by other investigators (6) was not indicative of maturity in the Sunbred 212 sunflower hybrid grown in this study.

The fatty acid composition of the oils from the spring and summer plantings are shown in Table 1. The oleic acid content of the seed oil was maximum at 21 days after petal drop for both the spring and summer plantings. The linoleic acid content of the oil did not vary significantly for the spring crop, except at 21 days after petal drop, which was the lowest value obtained. For the summer plantings, linoleic acid content was significantly highest at 28 days. The oils from the spring planting generally contained more oleic than linoleic acid, except at the 7 day harvest, but the converse was true of the oils from the summer plantings. These observations suggest that a way to obtain an oil with a desired fatty acid composition is to vary the planting date of the sunflower seed. Such a difference between spring and fall sunflower seed oils has been observed between southern and northern grown sunflowers (2, 8, 10). However, no observations with such differences in the same growing area during the same year at different planting dates have been recorded. Temperature differences could

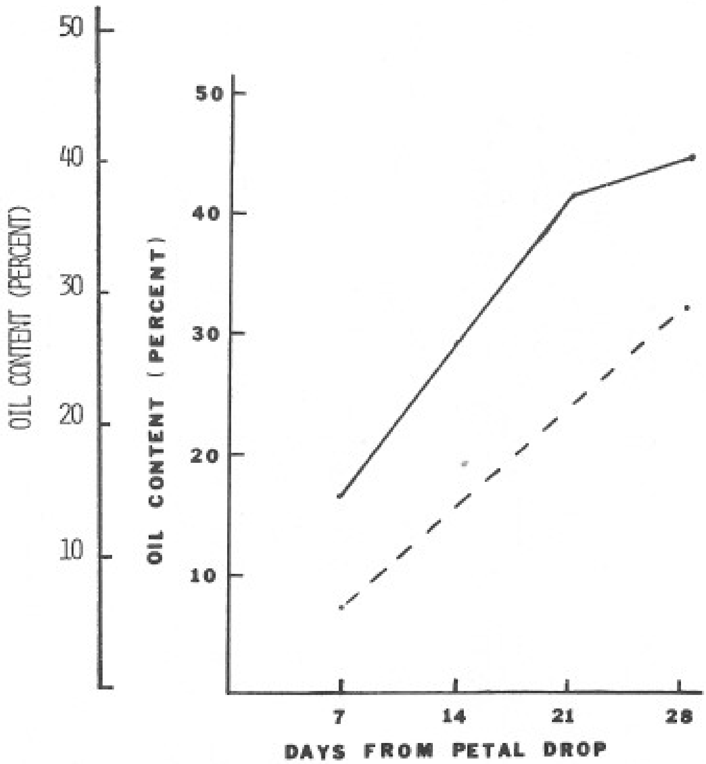

Fig. 1. Oil content on dry weight basis of the maturing sunflower seed after petal drop (0 day) for spring (———) and summer (- - - - - -) planted seed.

explain the difference in proportion of oleic and linoleic acids in oils from the spring and summer plantings (Table 1).

Differences in oil composition make usage in a wide range of food applications possible. Oil containing a high content of linoleic acid will find more usage in margarines, salad dressings and salad oils. Spring produced oil with a higher oleic acid content is stable when heated (1) and will find more acceptance for production of snacks, potato chips and other fried foods. Palmitic acid decreased significantly in oils from the summer plantings as the seed approached maturity. Significant increases in stearic acid content were noted only at 28 days for the summer plantings. Putt et al., (8) noted some association of oleic and linoleic with stearic acid; however, no correlation was noted in these studies.

Generally the protein content of the seed increased from 15.7 to 18.1 percent as the seed matured for the spring planting and 15.4 to 20.9 percent for the summer planting. The seed dry weight increased with seed development, as would be expected. On the 28th day from petal drop the sunflower heads were completely brown, a characteristic that may be of value indicating approaching maturity of sunflowers grown in Southern Texas.

Table 1. Fatty acid composition of the oil from developing sunflower seeds and mean air temperatures, spring and summer plantings 1976.

Days after petal drop	Fatty acid composition (%) [1]								Mean air temperature (°C) [2]	
	Palmitic		Stearic		Oleic		Linoleic		Spring planted (Spring harvested)	Summer planted (Fall harvested)
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer		
7	8.4bc	12.8a	4.1b	5.2b	22.5d	25.4d	35.0d	56.6b	28.4	18.6
14	6.7bcd	12.0a	4.7b	5.2b	55.1b	26.1d	33.6d	56.7b	25.4	20.8
21	6.5cd	9.3b	3.5b	5.0b	59.8a	32.8c	30.2e	52.9c	28.3	21.1
28	6.5cd	5.0d	3.5b	7.2a	55.4b	24.2d	43.7d	63.6a	28.2	14.9

[1] Mean separation by Duncan's multiple range test, 5% level.

[2] Mean air temperature for 7 day intervals from petal drop.

We conclude that physiological maturity of the Sunbred 212 sunflower hybrid based on seed size, maximum oil content and fatty acid (oleic or linoleic) content occurs after the 28th day from petal drop. Sunflower seed oil high in polyunsaturates and with a predetermined fatty acid composition high in either linoleic or oleic acid content can be produced in the same area by varying the planting dates within the same year.

LITERATURE CITED

1. Anderson, W. K. 1975. Maturation of sunflower. Australian J. of Exp. Agri. and Animal Husbandry. 15:833-838.
2. Earle, F. F., C. H. Vanetten, T. F. Clark, and I. A. Wolff. 1968. Compositional data on sunflower seed. J. Am. Oil Chem. Soc. 45:876-879.
3. Fick, G. N. and D. C. Zimmerman. 1973. Variability in oil content among heads and seeds within heads of sunflowers (*Helianthus annuus* L.) J. Am. Oil Chem. Soc. 50:529-531.
4. Heilman, M. D., E. R. Stein and R. V. Cantu. 1977. Yield, growth characteristics, and oil content of four hybrid sunflower cultivars. J. Rio Grande Valley Hort. Soc. 31:147-151.
5. ____________, C. M. Heald, J. R. Coppedge and J. A. Robertson. 1975. Fall production of oil type sunflower in the Lower Rio Grande Valley of South Texas. J. Rio Grande Valley Hort. Soc. 29:99-108.
6. Johnson, B. F. and M. D. Jellum. 1972. Effect of planting date on sunflower yields, oil and plant characteristics. Agron. J. 64:747-748.
7. Official and Tentative Methods of the American Oil Chemists Society. Vol. I. Third Edition, AOCS, Champaign, IL 1974.
8. Putt, E. D., B. M. Craig, and R. B. Carson. 1969. Variation in composition of sunflower oil from composite samples and single seeds of varieties and inbred lines. J. Am. Oil Chem. Soc. 46:126-129.
9. Robertson, J. A. 1974. Collaborative study of the determination of total oil in sunflower seed. J. Am. Oil Chem. Soc. 51:223A-225A.
10. ____________. 1972. Sunflowers: America's neglected crop. J. Am. Oil Chem. Soc. 41:239-244.
11. ____________ and W. H. Morris, III. 1976. Research on sunflower oil and kernels. Proc. Sunflower Forum. 34-31.
12. ____________, G. W. Chapman, Jr. and R. L. Wilson, Jr. 1978. Relation of days after flowering to chemical composition and physiological maturity of sunflower seed. J. Am. Oil Chem. Soc. 55:266-269.
13. Supelco, Inc. Bulletin 721 B. Esterification 1775.
14. Zimmerman, D. C. and G. N. Fick. 1973. Fatty acid composition of sunflower (*Helianthus annuus* L.) oil as influenced by seed position. J. Am. Oil Chem. Soc. 50:273-275.

Relation Between Soluble Protein Content and Levels of Resistance to Tobacco Etch Virus in Pepper Breeding Stocks

Eduardo R. Stein and Ben Villalon
Research Chemist, Southern Region, SEA, AR, USDA, Weslaco, TX 78596
and Associate Professor, Virology, Texas A&M University
Agricultural Research and Extension Center, Weslaco, TX 78596

ABSTRACT

Leaves from 13 greenhouse-grown, 40-day-old pepper breeding stocks, susceptible and non-susceptible to tobacco etch virus (TEV), were assayed for levels of soluble leaf protein. On a TEV resistance scale of 1-10, breeding stocks with the highest level of resistance to TEV had a higher protein content than those with low levels of resistance, except for PI 264281. In general, protein content correlated well with the resistance scale.

Viruses consist largely of protein that covers the obligatory component nucleic acid. Viruses lack the enzymes necessary for independent metabolism. Upon entry into a competent living cell, they can initiate a change in the metabolic pattern of the cell that will lead to the production of virus nucleic acid and virus protein. Viruses thus use host-cell enzyme systems and metabolites to elicit virus replication (11).

Little is known about the physical or biochemical basis for the susceptibility of peppers, *Capsicum annuum* L., to viral infection or of their resistance to such infection. Simmons and Moss suggested that the resistance of the Italian El variety to viral infection is due to the presence of a virus inhibitor (16). No specific inhibitor of virus Y was found in other resistant peppers (3). Different varieties and classes of pepper differ in their resistance to various strains of the virus (15).

Many species of plants contain inhibitory substances that interfere with the viral-infection process. Some of these substances have been identified and include proteins (7, 9, 13, 17, 19), polysaccharides (4, 5, 12), tannins (2), and flavones (6) or related compounds. Virus protein can also be an inhibitor of infectivity. Bawden and Pirie (1) demonstrated that a low-molecular-weight fraction of tobacco mosaic virus (TMV), when added to viral inoculum, effectively inhibited infection by TMV. Santilli et al. (14) and Holoubeck (8) observed that the effect was nonspecific and highly dependent on concentration.

Since proteins have been identified as substances that interfere with the viral infection process in some plant species a preliminary investigation of leaf proteins in pepper breeding stocks was initiated. Several pepper genetic stocks observed to be resistant or susceptible to tobacco etch virus (TEV) through standard viral screening techniques (18) at the Texas Agricultural Experiment Station at Weslaco were investigated.

MATERIALS AND METHODS

Seeds from 13 pepper breeding stocks were planted, 5 seeds per pot, in small pots that contained peat perlite Cornell mix. All pots were kept in a greenhouse and subject to springtime photoperiod and environmental conditions. The pots were watered at regular intervals. At 40 days from planting, 3 g of leaves of approximately the same size and age were excised from the seedlings, composited, placed in a plastic bag, and stored at $0^{\circ}C$. Three composited samples from each stock were prepared. Each composited pepper-leaf sample was ground separately in cold mortar with 5 ml of a $0\text{-}5^{\circ}C$ solution, pH 8.0, that contained 0.1 M tris buffer, 0.006 M ascorbic acid, and 0.006 M cysteine. Each mixture was then homogenized in a cold glass tissue grinder and centrifuged at 10,000 x g for 20 minutes. Proteins dissolved in the supernates were precipitated by adding 7% perchloric acid. The protein precipitates were washed twice with water and twice with 95% ethanol. The precipitates were dissolved in 3.0 ml of 0.5 N sodium hydroxide and diluted to a known volume with water. Triplicate protein determinations on each of the supernates were conducted by the Lowry Method (10).

RESULTS AND DISCUSSION

The levels of soluble protein in the leaves of each pepper breeding stock are tabulated in Table 1. Also shown are the numbers on the resistance scale that were assigned each breeding line by the breeder after several years of testing. Highest resistance to TEV is indicated by the number 9, lowest resistance by 1. Breeding stocks 1534 and AC 2207 with a high resistance to TEV had the highest protein content. An exception to this observation was stock PI 264281 with a resistance number of 9 but a protein content significantly different than stocks 1534 and AC 2207. The two most TEV susceptible breeding stocks, Yolo Y and Grande Rio 66, also had the lowest protein content.

A strong correlation of 0.90 ($P < 0.001$) between protein content and resistance rating was found. The regression coefficient for this linear relationship is 5.23 with a standard error of 0.75 for the regression.

This preliminary observation indicates the potential of soluble leaf protein as a screening technique to determine resistance of pepper breeding stocks to TEV. However, a more extensive study of pepper breeding stock needs to be conducted on both field-grown and greenhouse grown seedlings so that the reliability of this method can be properly assessed and desired protein levels that correlate well with resistance be established.

LITERATURE CITED

1. Bawden, F. C. and N. W. Pirie. 1957. The activity of fragmented and reassembled tobacco mosaic virus. J. Gen. Microbiol. 17:80-95.

Table 1. Soluble leaf protein and resistance rating to TEV in pepper breeding stock.

Breeding stock	Source	Protein mg/g fresh tissue[z]	Resistance rating
1534	California	3.32 a	9
AC 2207	California	3.09 ab	9
Agronomico	Brazil	2.83 bc	7
Casca Dura	Brazil	2.82 bc	7
SC 46252	Florida	2.78 bc	8
Avelar	Florida	2.70 bc	7
PI 342947	Georgia	2.56 cd	9
PI 264281	Georgia	2.45 cd	8
Tobasco	Louisiana	2.38 cd	5
Bencho	Mexico	2.28 cd	4
Anaheim Mild	California	2.14 d	3
Yolo Y	Florida	1.69 e	1
Grande Rio 66	Texas	1,48 e	1

[z] Mean of triplicate determinations from each of three extractions.
Means followed by the same letter do not differ significantly at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

2. Cheo, P. C. and R. C. Lindner. 1964. *In vitro* and *in vivo* effects of commercial tannic acid and geranium tannin on tobacco mosaic virus. Virology 24:414-425.
3. Cook, A. A. 1968. Virus disease resistance in some Capsicum species from South America. Plant Dis. Rep. 52:381-383.
4. Ebrahim-Nesbat, F. and F. Nienhaus. 1972. Beeinflussung von Tabaknosaikvivus and Gurkenmosaikvirusinfektion durch hemmende Prinzipien in flanzenextrakten. Phytopathol. Z. 73:235-250.
5. El-Kandelgy, S. M. and R. D. Wilcoxson. 1966. Effect of red clover flower extract and glucose on infection of *Gomphrena globosa* by red clover vein mosaic virus. Phytopathology. 56:832-837.
6. Fisher, H. and F. Nienhaus. 1973. Virushemende Prinzipien in Patrikapflanzen (*Capsicum annuum* L.) Phytopathol. Z. 78:25-41.
7. Hampton, R. E. and R. W. Fulton. 1961. The relation of polyphenol oxidase to instability *in vitro* of prune dwarf and sour cherry necrotic ringspot virus. Virology 13:44-52.
8. Holoubek, V. 1964. Effect of tobacco mosaic virus protein on mosaic virus infectivity. Nature 203:499-501.
9. Kassanis, B. and A. Kleczkowski. 1948. The isolation and some properties of a virus-inhibiting protein from *Phytolacca esculenta.* J. Gen. Microbiol. 2:143-153.
10. Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein measurement with the Folin phenol reagent. J. Biol. Chem. 193:265-275.

11. Matthews, R. E. F. 1970, Plant virology. Academic Press, Inc., New York.
12. Moraes, W. B. C., E. M. Martins, E. Conti, and A. R. Oliveira. 1974a. The inhibitory activity of extract of *Abutilon straitum* leaves on plant virus infection. I. Isolation and some properties of the inhibitor. Phytopathol. Z. 81: 145-152.
13. Santilli, V. 1964. The relation of leaf ribonuclease activity on TMV infection. Paper given in symposium, host parasite relations in plant pathology, Budapest, Hungary.
14. ________ ., J. Piacitelli and J. H. Wu. 1961. The effect of tobacco mosaic virus protein on virus incubation period and infectivity. Virology 14:109-123.
15. Simmonds, N. W. and E. Harrison. 1959. The genetics of reaction to pepper vein-banding virus. Genetics 44:1281-1289.
16. Simons, J. N. and L. M. Moss. 1963. The mechanism of resistance to potato virus y infection in *capsicum annuum* variety Italian El. Phytopathology 53: 684-691.
17. Smookler, M. M. 1971. Properties of inhibitors of plant virus infection occurring in the leaves of species of *Chenopoliales.* Ann. Appl. Biol. 69:157-168.
18. Villalon, B. 1975. Virus diseased of bell peppers in South Texas. Plant Dis. Rep. 59:858-862.
19. Wyatt, S. D. and R. J. Shepherd. 1969. Isolation and characterization of a virus inhibitor from *Phytolacca* americana. Phytopathology 59:1878-1794.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Midday Surface Temperatures and Energy Exchanges in a Residential Landscape

P. R. Nixon, B. G. Goodier, and W. A. Swanson
Agricultural Engineer, Research Associate (Texas A&M Cooperator), and Biological Technician, respectively,
Soil and Water Conservation Research, Subtropical Texas Area, Southern Region, SEA, USDA, Weslaco, TX 78596

ABSTRACT

Midday surface temperatures of residential landscape and structural features indicated by a radiation thermometer at Weslaco, Texas, ranged from 6.9°C below to 36.8° above air temperature on warm days. Shaded vegetation and continuously shaded constructed features were below air temperature. Sunlit structural features and nonvegetated parts of the landscape were warmer than vegetated features, with a house roof being the hottest. Prominent energy transfer processes that balanced the midday incoming radiational energy from solar and atmospheric sources were: (1) emitted radiation from all features of the landscape, (2) evapotranspiration from vegetation (represented by a lawn), (3) heating of the ground and air by nonvegetated surfaces (represented by a concrete driveway), and (4) reflected solar radiation from the driveway. In addition to having the most intense reflected and emitted radiations, the driveway put about four times more energy per unit area into heating the ground and air than did the lawn. Examples of the beneficial reduction of air conditioning loads by vegetative shading of a dwelling are discussed.

Additional index words: Vegetation temperatures, Landscape heating, Net radiation, Energy balance, Air conditioning

---

Many people are aware of the pleasure and comfort that a home landscape brings. They appreciate what plants do to shade, cool, color, scent and protect their environment (4). Leonard (7) made the generalized statement that well watered vegetation of mostly trees reduced air temperature on a hot dry day about 3.5°C. In the localized microclimate of a home landscape, the effect can be even more pronounced.

White et al. (16) in a recent study of the greater St. Louis area indicated the extent to which vegetated areas have lower surface temperatures than areas dominated by constructed features. Data obtained by aircraft on two August days showed that at 1400 hours local time the average surface temperature in residential areas (including roofs and streets) was 5 to 7°C warmer than that in cropped agricultural areas. In contrast, the average surface temperature in commercial and industrial areas was 12°C and 13°C warmer, respectively, than the agricultural areas.

Radiation, in addition to air temperature and air movement, plays an important role in human comfort. The thermal exchange rates between man and his environment are described by this heat balance equation (calories per square centimeter body surface per minute) (1):

$$S = M - (\pm W) - V \pm R_b \pm C \qquad [1]$$

where S is change in intrinsic body heat, M is body metabolism, W is mechanical work accomplished, V is evaporative heat loss caused by evaporation of body fluids, R_b radiative heat gain or loss, and C is convective heat gain or loss. Normally S remains near zero.

The ongoing energy exchange in a landscape is written (calories per square centimeter per minute) (9, 13):

$$R_n = R_s - R_{sr} + R_a - R_{ar} - R_e = \pm G \pm A \pm E + P - M \qquad [2]$$

where

R_n	=	Net radiation (difference between radiation of all wavelengths received by the landscape and radiation of all wavelengths given up by the landscape)
R_s	=	Solar radiation (direct and diffuse short wavelength)
R_{sr}	=	Reflected solar radiation
R_a	=	Atmospheric radiation (emitted long wavelength)
R_{ar}	=	Reflected atmospheric radiation
R_e	=	Surface emitted long wavelength radiation
G	=	Heat to or from object or ground
A	=	Heat to or from the air
E	=	Latent heat of evaporation (or release by dew formation)
P	=	Energy of photosynthesis
M	=	Energy liberated by metabolic processes

The daytime relationships of equation [2] are shown in Fig. 1. Energy exchange at the landscape's surface involves short-wavelength (solar) electromagnetic radiation orgininating from the sun (R_s and R_{sr}); long-wavelength electromagnetic radiation emitted by the atmosphere and landscape surfaces (R_a, R_{ar} and R_e); and transformed radiant energy that results in the heating of the ground and air (G and A), and in bringing about evaporation (evapotranspiration) (E), and photosynthesis (P). Energy liberated by metabolic processes (M) is customarily neglected because it is small in comparison with the other processes. The directions of the daytime energy flow to or from the landscape surface are shown in the figure. Natural ongoing adjustments cause the rate at which energy is leaving a surface in various forms to be equal to the rate at which energy is arriving at the surface. This research examines the midday energy exchange at Weslaco, Texas, on a somewhat hot, humid day and on a day that was milder and less humid.

MATERIALS AND METHODS

We measured the surface temperatures surrounding a Weslaco, Texas, (Lat. 26.2° N, Long. 98.0° W) home at midday on 3 days and observed energy exchanges on the last two dates. The 200 m^2 one-story home was centered on a city lot measuring 29 m by 38 m. The surface temperatures of vegetative and constructed features of the residential landscape were determined with a hand-held, noncontact radiation thermometer (Barnes Instatherm, Model 14-220-1, 2.8° field of

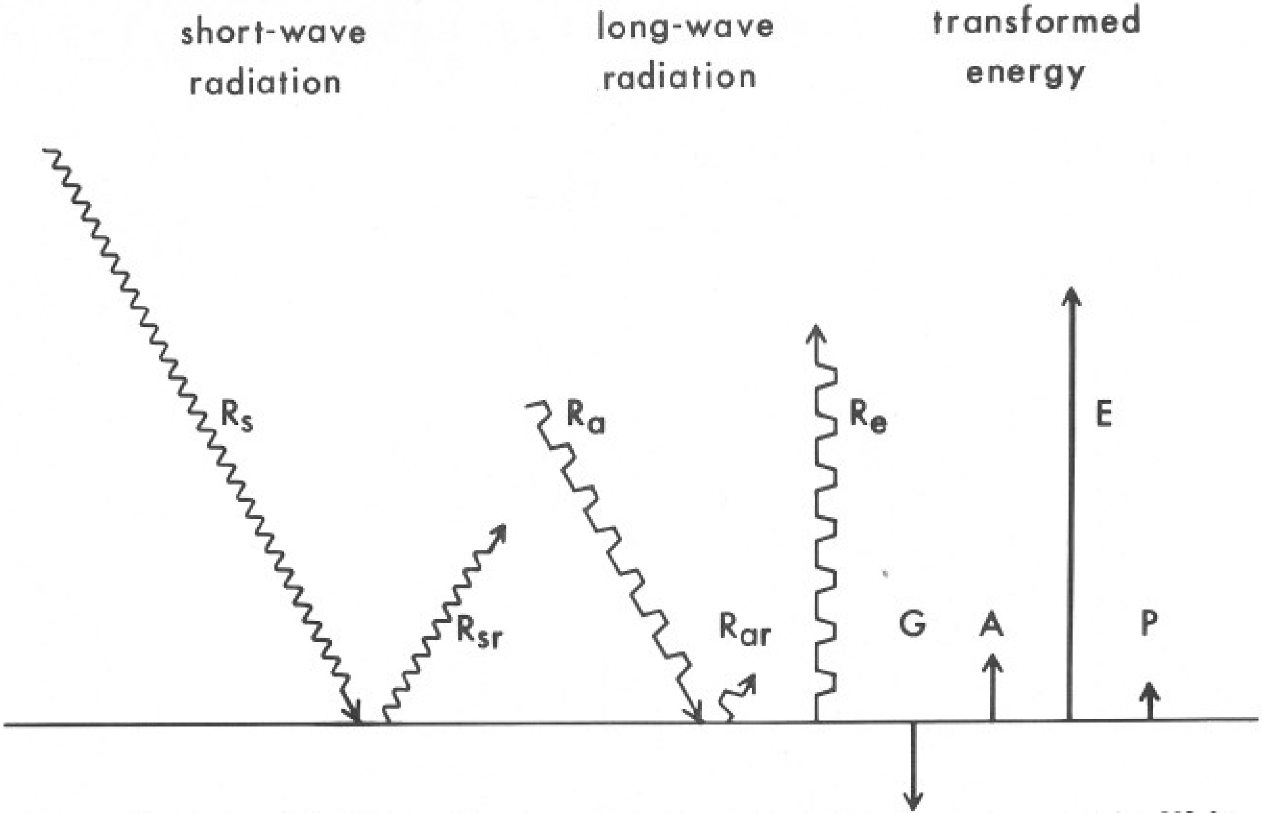

Fig. 1. Schematic representation of the daytime energy exchange at the landscape's surface. Refer to equation [2] for symbol descriptions.

view). (Trade names and company names are included for the readers' benefit and do not imply an endorsement or preferential treatment of the product by the U. S. Department of Agriculture.) The radiation thermometer determines surface temperature by measuring radiant emittance which is related to surface temperature by the Stefan-Boltzmann law.

Solar radiation and reflected short-wavelength radiation were measured with an Eppley Model 8-48 temperature compensated pyranometer. Net radiation was directly measured with a Fritschen-type miniature net pyrradiometer, and ground heat flux was obtained with three National Instrument Laboratory Type HF-2 heat flow discs. All instruments but the heat flow discs were exposed at 0.5 m above the surfaces. The heat flow discs were about 5 mm below the soil surface. A Digitec digital millivolt-meter, Model 251-3, measured the output of the instruments.

The surface temperatures of landscape features were measured on September 18, October 3 and October 16. The radiation rates over a St. Augustine grass lawn and a concrete driveway were observed at the same time as the surface temperatures were being obtained on October 3 and October 16. Radiation and surface temperature were measured only when clouds did not obscure the sun. The solar radiation intensity exceeded clear-day values during sunshine periods on October 3 because solar radiation was concentrated by reflection off of clouds in addition to the normal direct beam and diffuse amounts. However, the main reason October 3 had higher radiation rates than October 16 is that the sun elevation was higher on the 3rd (about 58.4 vs 53.6 degrees above the horizon). Atmospheric radiation (R_a) was considered as the difference between total incoming radiation of all wavelengths ($R_s + R_a$) (measured with Gier and Dunkle pyrradiometer) and short-wavelength solar radiation (R_s) (measured with an Eppley pyranometer) at the Soil and Water Research Farm, Weslaco, at the time of the experiment on October 3. Atmospheric radiation for October 16 was calculated by the Brutsaert method (2) using data from the environmental station at the Research Farm.

The different conditions of cloudiness, air temperature, relative humidity, wind speed and soil moisture that prevailed on the three dates are listed in Table 1. The air temperature and humidity observations were made with an aspirating psychrometer at 1.5 m above the ground. These observations were made in the shade of a tree that had open exposure to the wind. The wind speed was estimated at the 1.5 m height.

RESULTS

Surface temperatures. Table 2 shows the temperature differences between the various features of the home landscape, as indicated by the radiation thermometer, and the prevailing air temperature. The actual surface temperatures may have been about 1°C higher than indicated by the radiation thermometer because the instrument was calibrated for black-body long-wave radiation and the emissivities of the landscape features were less than the theoretical 1.00 (17). To some extent reflected atmospheric radiation, R_{ar}, (Fig. 1), which the instrument included with its measurement of the emitted radiation, R_e, compensated for the error (8). Each value in Table 2 represents the average of 3 to 5 readings.

Table 1. Conditions prevailing when surface temperatures and energy exchanges were observed at Weslaco, Texas.

Conditions	September 18	October 3	October 16
Observation period [1]	1430 - 1540	1330 - 1410	1345 - 1415
Sky condition, % clouds	0	10 - 40	5 - 15
Air Temperature, °C	33.6 - 34.2	31.4 - 30.6	27.0 - 27.5
Air relative humidity, %	46 - 43	76 - 78	42 - 40
Wind speed, m/sec	5	>1	>1
Soil moisture content	low	medium	high

[1] Central daylight time.

Table 2 shows that vegetation temperature was typically near air temperature. In some cases, however, the equivalent black-body temperatures of sunlit grass and plants ranged up to 9.2°C above the bulk air temperature. Part of the apparent positive temperature difference was caused by wind-sheltered locations and their associated microclimates, where air temperatures were above the reference temperature measured in the open. Evaporative cooling through evapotranspiration lowered the temperature of vegetation in shaded locations to several degrees below ambient; shaded grass that had been sprinkled 5 min before was as much as 6.9°C coolor.

Temperatures of nonliving features of the landscape that were exposed to sunshine greatly exceeded air temperature by midday. Moist soil was 10°C above air temperature, and dry soil was more than 21°C warmer. Table 2 shows that the temperatures of sunlit surfaces of a brick patio, concrete driveway, asphalt paved street and a brushed aggregate walk ranged between 9 and 20°C above air temperature. When brick and concrete surfaces were continuously shaded, their temperatures lagged air temperature by 3°at midday. The warmest feature of the landscape was the composition shingle home roof whose temperature on the last date exceeded air temperature by 36°C.

Radiation exchanges. The measured energy rates during October 3 and October 16 are noted in Table 3. Additional energy exchange elements listed in the table were obtained by applying the following representative values from the literature to the energy exchange equation [2]-

Long-wave reflectivity of concrete = 5.0% (3, 8)

Long-wave reflectivity of lawn = 2.7% (3, 8)

Bowen ratio of energy heating air to evaporative energy over lawn = 0.12 (5, 6, 12, 14)

Photosynthesis of lawn - 2.0% of solar radiation (9, 11, 13)

The outgoing long-wave radiation, consisting of reflected atmospheric radiation (R_{ar}) plus radiation emitted by the surface (R_e), was considered to be the black-body radiation rate corresponding to the temperature indicated by the radiation thermometer.

Table 3 gives the results that were obtained when the measured and representative values were put into the energy exchange equation [2]. Obviously the

Table 2. Difference between midday surface temperatures of residential landscape features indicated by a radiation thermometer at Weslaco, Texas, and prevailing air temperatures.

Surface	Sept. 19	Oct. 3	Oct. 16
		°C	
Grass, St. Augustine, sunlit	5.5	3.8	5.0
Grass, St. Augustine, tree shaded	-4.0	-1.0	-4.2
Grass, St. Augustine, sunlit, after sprinkler wetting	-4.5		
Grass, St. Augustine, shaded, after sprinkler wetting	-6.9		
Bottlebrush, *Callistemon rigidus*, tree shaded	-2.8	-1.0	
Chinese tallow, *Sapium sebiferum*, underside	-2.9		
India hawthorn, *Raphiolepis indica rosea*, sunlit	2.4	4.0	5.2
India hawthorn, *Raphiolepis indica rosea*, tree shade	-3.9	-1.5	-1.5
Live oak, *Quercus virginiana*, underside	-2.9	-3.0	0
Nandina domestica, sunlit		3.5	7.8
Nandina domestica, house shaded			.8
Natal plum, *Carissa Arduina var. nana*, sunlit		7.5	9.2
Pittosporum Tobira var. variegata, sunlit	.6	1.5	
Pittosporum Tobira var. variegata, tree shaded	-2.8	-1.5	
Podocarpus macrophylla, sunlit	.1		
Podocarpus macrophylla, tree shaded	-3.4	-2.2	
Soil, bare, dry continuously sunlit	21.1		
Soil, bare, dry surface, tree shaded	-4.2		
Soil, bare, moist, continuously sunlit		10.0	
Patio, concrete, continuously shaded	-3.8	-3.5	
Patio, brick, continuously shaded	-3.8	-3.5	
Patio, brick, continuously sunlit	16.3	12.8	
Driveway, concrete, shaded for previous 2.5 hr.	2.1		
Driveway, concrete, continuously sunlit	9.6	14.0	12.2
Street, asphaltic pavement, continuously sunlit	19.6		20.2
Walk, brushed aggregate, continuously sunlit	9.6	16.2	15.0
Wall of house, brick, continuously shaded	-2.8	-1.2	
Wall of house, brick, continuously sunlit	8.4		12.2
Wall of house, cedar, sunlit	10.1		
Fence, 2 cm cedar, continuously sunlit		21.0	
Roof, composition, dark gray, south facing, sunlit	24.0		
Roof, composition, dark gray, west facing, sunlit	29.1		36.8
Roof, composition, dark gray, west facing, 90% shading 1 hr.	7.8		

Table 3. Midday flow of energy in St. Augustine lawn and concrete driveway areas of a Weslaco, Texas residential landscape on October 3 and October 16. Values of the latter date are in parentheses. The data are on the basis of a horizontal surface.

Energy Form	cal $cm^{-2}min^{-1}$	
	Lawn	Driveway
Incoming Radiation		
Solar radiation (direct and diffuse)[1], R_s	1.315 (1.161)	1.315 (1.161)
Long-wave atmospheric radiation, R_a	.673 (.555)	.673 (.555)
Outgoing Radiation		
Reflected solar ratiation[1], R_{sr}	.341 (.284)	.530 (.402)
Reflected atmospheric radiation, R_{ar}	.018 (.015)	.034 (.028)
Emitted radiation, R_e	.713 (.692)	.799 (.749)
Net Radiation		
Directly measured net radiation[1], R_n	.945 (.735)	.607 (.534)
Transformed Energy		
Heat to ground[1], G	.087 (.055)	[.625 (.537)][2]
Heat to air, A	.086 (.069)	
Latent heat of evaporation, E	.717 (.578)	0 0
Photosynthesis, P	.026 (.023)	0 0

[1] Measured values.
[2] Combined heat to ground and air.

above representative values do not exactly represent our situation which changed from hour to hour and day to day, but their use provides reasonable estimates of the magnitudes involved. In all cases the calculated net differences between incoming and outgoing radiation of the four data sets of Table 3 are within ±3% of the independently measured net radiations. The energy transformations that corresponded to net radiation (difference between incoming and outgoing radiation) went into heating the ground and air and caused evaporation and photosynthesis.

Table 3 shows that the concrete driveway reflected more solar and long-wave radiation than the grass lawn. Likewise the driveway emitted more long-wave radiation. It was assumed for the driveway that evaporation (E) and photosynthesis (P) were zero; hence, all the transformed energy heated the ground (concrete) and air. The table shows that at midday the driveway put about four times more energy per unit area into heating the ground and air than did the lawn.

In Table 4, the midday energy partitioning is expressed as percentages of the total incoming radiation (R_s + R_a given in Table 3). The prominent processes which in magnitude exceeded a quarter of incoming radiational energy are: the emitted radiations from the lawn and from the driveway, reflected solar radiation from the driveway, evapotranspiration from the lawn, and the combined heating of the ground and air at the driveway. Heating of the ground and

Table 4. Midday flow of energy in St. Augustine lawn and concrete driveway areas of a Weslaco, Texas residential landscape on October 3 and October 16, expressed as percent of total incoming radiation. Values of the latter date are in parentheses.

Energy Form	% total incoming radiation	
	Lawn	Driveway
Income Radiation		
Solar radiation (direct and diffuse), R_s	66 (68)	66 (68)
Long-wave atmospheric radiation, R_a	34 (32)	34 (32)
Outgoing Radiation		
Reflected solar radiation, R_{sr}	17 (17)	27 (23)
Reflected atmospheric radiation, R_{ar}	1 (1)	2 (2)
Emitted radiation, R_e	36 (40)	40 (44)
Net Radiation		
Directly measured net radiation, R_n	48 (43)	31 (31)
Transformed Energy		
Heat to ground, G	4 (3)	[31 (31)][1]
Heat to air, A	4 (4)	
Latent heat of evaporation, E	36 (34)	
Photosynthesis, P	1 (1)	

[1] Combined heat to ground and air.

air in the lawn area was minor in comparison with total incoming energy. The reflected atmospheric radiation and photosynthesis were very small in terms of the relative amounts of energy.

DISCUSSION

Newbauei (10) and others have recognized that the shade from trees grown on the east and west sides of buildings greatly enhances the effectiveness of structures that are designed for natural cooling. The value of shading the brick wall of a house is shown in Table 2 by the data of September 19 for shaded and sunlit conditions. The -2.8 and 8.4°C of the table become 31.1 and 42.3°C when adjusted for the 33.9°C existing air temperature.

Air conditioning engineers consider that the air conditioning load of a building is proportional to the difference between the outside and the inside surface temperatures of the walls and other exterior parts (1). If we assume that the inside wall temperatures were maintained at 26°C in the home of this study, then the temperature gradients through the shaded and sunlit walls were 5.1°C (31.1 - 26.0) and 16.3°C (42.3 - 26.0), respectively. According to these calculations only one-third as much heat flowed into the home through the shaded wall as compared to the sunlit wall.

Similar comparisons can be made using the September 19 data of the 90% tree-shaded west-facing roof and the sunlit west-facing roof (Table 2). If we assume an inside ceilng temperature of 27°C, then temperature gradients through roof, attic and ceiling are 14.7 and 36.0°C, respectively. This suggests that the shaded roof contributed less than half as much heat to the home as the sunlit roof.

We recognize that these comparisons are not precise. Redistribution of energy within the attic from the different roof aspects, and attic ventilation are factors. The statement that heat flow is proportional to the difference between outside and inside temperatures is true for steady state conditions; but morning heat-flow lag and afternoon sustained heating rates occur because of the thermal inertia of construction materials in a dynamic environment. Differences in conductive, convective and radiative conditions from situation to situation preclude sweeping generalizations that specify exact heat fluxes. Nevertheless the point we make is valid; great reductions of the air conditioning load result from shading a house.

A person standing in the open is subject to solar and atmospheric radiation from above and reflected and emitted radiations from below. The amount of radiation from below, tabulated as outgoing radiation in Tables 3 and 4, can have an important effect on human comfort because it represents a considerable amount in relation to the net balance of equation [1]. The outgoing radiation from the driveway was about 23% more than from the lawn according to the averaged values of the two dates reported in Table 3. Not only did Waggoner (15) find that a man standing on a lawn lost heat more rapidly than when on a parking lot, but his heat loss over a lawn was greater than on a beach. The application is clear both as regards human comfort and home air conditioning; large unshaded bare areas around homes (driveways, walks, bare ground) should be avoided in preference to lawn or other vegetated surfaces.

We have shown the benefits of shade and vegetated surfaces, but a word of caution is necessary in connection with landscape planning. Provision for sufficient natural air circulation should be included in the design because for human comfort it is needed to help the body maintain a favorable thermal exchange rate (15). During hot weather air movement maintains the convective heat loss from the body and aids in the evaporative heat loss by carrying water vapor away from the body (the C and V terms of equation [1]). A landscape design that shades the home in summer while at the same time providing good air circulation contributes much to comfort and reduced air conditioning cost.

LITERATURE CITED

1. American Society of Heating, Refrigerating and Air Conditioning Engineers. ASHRAE Handbook of Fundamentals. 1976. The Society. New York. pp. 688.
2. Brutsaert, W. 1975. On a derivable formula for long-wave radiation from clear skies. Water Resour. Res. 11(5):742-744.
3. Buettner, K. J. K., and C. D. Kern. 1965. The determination of infrared emissivities of terrestrial surfaces. J. Geophys. Res. 70(6):1329-1337.

4. Cathey, H. M. 1972. Plants in the living environment to lift the spirits of man, p. 2-4. In: Landscape for living. 1972 Yearbook of Agriculture. U. S. Dept. Agr., Washington, D.C.
5. Fritschen, L. J. 1965. Accuracy of evapotranspiration determinations by the Bowen ratio method. Int. Ass. Sci. Hydrol. Bull. 10(2):38-48.
6. ____________ ., and C. H. M. Van Bavel. 1963. Experimental evaluation of models of latent and sensible heat transport over irrigated surfaces. Int. Ass. Sci. Hydrol., Comm. for Evaporation. 62:159-171.
7. Leonard, R. E. 1972. Making our lives more pleasant - plants as climate changers, p. 5-9. In: Landscape for living. 1972 Yearbook of Agriculture. U. S. Dept. Agr., Washington, D.C.
8. Lorenz, D. 1966. The effect of the long-wave reflectivity of natural surfaces on surface temperature measurements using radiometers. J. Appl. Meterol. 5:421-430.
9. Munn, R. E. 1966. Descriptive micrometeorology. Academic Press. New York. pp. 245.
10. Newbauer, L. W. 1972. Shapes and orientations of houses for natural cooling. Trans. ASAE. 15:126-128.
11. Noggle, G. R. and G. J. Fritz. 1976. Introductory Plant Physiology. Prentice-Hall, Inc., Englewood Cliffs, N. J.
12. Oke, T. R. 1979. Advectively-assisted evapotranspiration from irrigated urban vegetation. Bound.-Layer Meteor. 15:167-174.
13. Sellers, W. D. 1965. Physical climatology. Univ. of Chicago Press, Chicago. pp. 272.
14. Suckling, P. W. 1980. The energy balance microclimate of a suburban lawn. J. Appl. Meteorol. 19:606-608.
15. Waggoner, P. E. 1963. Plants, shade and shelter. Connecticut Agr. Exp. Sta. Tech. Bull. 656.
16. White, J. M., F. D. Eaton, and A. H. Auer, Jr. 1978. The net radiation budget of the St. Louis metropolitan area. J. Appl. Meteorol. 17:593-599.
17. Wolfe, W. L. 1975. Differences in radiance: relative effects of temperature changes and emissivity changes. Appl. Optics. 14:1937-1939.

A Comparison of Declining Grapefruit Trees in South Texas with Blight-Affected Trees in Florida

H. K. Wutscher, Research Horticulturist
U. S. Department of Agriculture, SEA, AR, Orlando, FL 32803;
R. E. Rouse, Assistant Professor
Texas A&M University Research & Extension Center, Weslaco, TX 78596;
and J. Flowers, Citrus Manager
Rio Farms, Inc., Edcouch, TX 78538

ABSTRACT

Differences in leaf concentration of N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and Cl between declining and healthy 'Redblush' grapefruit trees on sour orange in two orchards near Monte Alto, Texas, indicate different reasons for the decline of the trees. A comparison with the leaf nutrient levels of healthy and blight-affected 'Marsh' grapefruit trees on rough lemon rootstock in Florida showed that the pattern of low K and high Na and Cl of blight-affected trees also was found in one, but not the other, location in the Lower Rio Grande Valley. Trees in Florida accumulated Zn and water-soluble phenolics in the trunk; the trees in one Texas orchard accumulated only phenolics. Differences in water uptake in absorption tests between healthy and declining trees were not significant in Texas.

Tree declines whose causes are unknown periodically appear in all citrus production areas. Blight, the most serious citrus production problem in Florida (7), falls into this category. Similar tree declines apparently exist in South America (9).

Visual symptoms of blight are unreliable; therefore, chemical and physical tests are necessary to determine tree status (3, 8). Blight reduces uptake of injected water and induces high levels of Zn and water-soluble phenolics in the wood with high Na, and Cl, and low K and Zn levels in the leaves (3, 8, 10). Heavy metals applied as nutrient sprays remain in the leaves and are not translocated as in healthy trees (10). We applied these criteria to two sets of declining trees in the Monte Alto area of the Lower Rio Grande Valley of Texas and compared them with blight-affected trees in Florida to determine whether declining trees in Texas were afflicted with blight.

MATERIALS AND METHODS

Thirty-leaf samples were collected for analysis in July and August 1979, from eight declining and eight healthy CES #3 'Redblush' grapefruit (*Citrus paradisi* Macf) trees on sour orange rootstock (*C. aurantium* L.) in Rio Farms' Areas 32 and 10. Five healthy and five declining trees were sampled in a grove of 'Marsh' white grapefruit (*C. paradisi*) on rough lemon rootstock (*C. limon* (L.) Burm. f.) near Clermont, Florida. Samples of the outer 2.5 cm of the trunk wood for Zn and water-soluble phenolics analysis (6) were taken from five declining and five healthy trees in Rio Farms' Area 32, from five declining and four healthy trees in Rio Farms' Area 10, and from five healthy and five declining trees in Clermont, Florida. We made water injections, using Cohen's method (2), in Texas in June, and in Florida in July 1979.

Calcium, Mg, Fe, Mn, Zn, Cu, and Mo in the leaves were determined (after dry ashing) by atomic absorption spectrometry, K and Na by flame emission spectrometry, N by the Micro-Kjeldahl method, P by the molybdivanadophosphoric acid method (2), Cl by electrometric titration, B by the curcumin colorimetric method (4), and S turbidimetrically (6). The wood was analyzed for Zn by atomic absorption and for water-soluble phenolics by spectrophotometry (8). Results were analyzed statistically by using the t-test.

Trees in Area 32 were 15 years old and spaced 3.3 m x 6.6 m. Before planting, the site was cut deeply in terracing the original hill for flood irrigation. The soil was a fine sandy loam with a pH of 6.4 to 7.7; there were shallow hardpans because of the terracing. Fertilization in 1979 consisted of a spring application of ammonium sulfate at the rate of 795 kg/ha. Copper and Zn were applied in the May postbloom insecticide spray. Emulsifiable S was applied as an insecticide in combination with a second Cu application in a June insecticide spray. The trees were flood-irrigated four times with Rio Grande water (900 ppm total salts) to supplement 26.7 cm (10.5 inches) rain which fell between January and July 1979. The declining trees in Rio Farms' Area 32, in two rows on a four-row terrace near the top of a hill, were concentrated within two rows; the end trees were healthy. The trees declined slowly, showing thin foliage, wilt and, eventually, dieback. There was profuse sprouting from the trunk and the main limbs. The symptoms were similar to those described by Lyons and Rouse (5). About a third of the 200 trees in the terrace showed symptoms of decline.

The trees in Area 10 were 6 years old and spaced 7.13 m x 6.09 m. The sandy clay loam, pH 6.7-7.6, had been leveled before planting. Ammonium sulfate at the rate of 795 kg/ha was applied in the spring of 1979. Zinc and Cu were applied in the postbloom insecticide treatment. Emulsifiable S, in combination with 12-12-12 foliar feed, was applied with the summer insecticide spray. Four irrigations with river water were used to supplement 45.7 cm (18 inches) of rainfall throughout the season. The trees in Area 10, in contrast to Area 32, were not crowded and declining trees were scattered at random throughout the 33-ha (80-acre) grove. The decline of the trees was rapid and wilt, yellowing, and leaf drop occurred on the whole canopy. About 1-2% of the trees in this block were affected.

The Florida samples came from a 54-year-old grove on a hillside with 3% slope, on deep sand, pH 6.7, typical of the Ridge section of the peninsula. The trees were fertilized in the winter and late spring of 1979 with 672 kg/ha of 16-0-16 fertilizer, with the N evenly divided between ammonium and nitrate, and the K in sulfate form. Boron, Zn, Mn, and Cu were applied in sprays. The grove was not irrigated and was exceptionally healthy until 3 years ago, when blight appeared in patches in an irregular pattern throughout the grove. About 10% of the trees are affected now, showing dull and thin foliage, small leaves and fruit, and dieback.

RESULTS

Only the declining trees in Florida had higher Zn levels in the wood than the healthy trees. Like the declining trees in Florida, those in Rio Farms' Area 10 accumulated more water-soluble phenolics than the controls (Table 1). The declining trees in Rio Farms' Area 32 had higher N, P, and K levels and lower Ca, S, Mn, Zn, and Cu levels in the leaves than healthy trees (Tables 2 and 3). There was no difference in Mg, Na, Fe, Cu, B and Mo. In contrast, the declining trees in Area 10 had higher concentrations of S, Na, Fe, Mn, Zn, Cu and Cl, and lower concentrations of K and Mg (Table 2 and 3). There was no difference in N, P, Ca, B and Mo.

Table 1. Wood Zn and water-soluble phenolics in declining and healthy grapefruit trees in Texas and Florida.

Location	Tree condition	Zn (ppm)	Water-soluble phenolics (mg/g)	Water uptake ml/24 hr
Rio Farms, Monte Alto, Texas				
Area 32	Declining	2^z	10.6^z	38^y
	Healthy	2	9.8	40
	$\underline{P}^x$	N.S.	N.S.	N.S.
Area 10	Declining	2^w	7.7^w	96^z
	Healthy	3	6.3	144
	$\underline{P}$	N.S.	0.10	N.S.
Clermont, Florida				
	Declining	14^z	9.1^z	27^z
	Healthy	3	6.9	284
	$\underline{P}$	0.02	0.10	0.01

^{z} Mean of 5 trees.
^{y} Mean of 6 trees.
^{x} Paired t-test.
^{w} Mean of 8 trees.

The K levels in the leaves of the declining grapefruit trees in Florida were lower, and the Na, Mn, and Cl levels higher, than in healthy trees. The N, P, Ca, Mg, S, Fe, Zn, Cu, B, and Mo levels were the same. The range in water uptake (Table 1) in Area 32 was 0-100 ml/24 hr for declining trees, and 0-120 ml/24 hr for healthy trees. In Area 10, declining trees absorbed 0-200 ml/24 hr, healthy trees 80-200 ml/24 hr. The sharp difference in water uptake between declining and healthy trees in Florida was not found in Texas.

Table 2. Macroelement leaf levels in declining and healthy grapefruit trees in Texas and Florida.

Location	Tree condition	N^z (%)	P^z (%)	K^z (%)	Ca^z (%)	Mg^z (%)	S^z (%)	Na^z (ppm)
Rio Farms, Monte Alto, Texas								
Area 32	Declining	2.86^z	0.163^z	1.78^z	3.90^z	0.374^z	0.302^z	645^z
	Healthy	2.45	0.122	0.96	4.81	0.351	0.337	749
	$\underline{P}^y$	0.01	0.01	0.01	0.01	N.S.	0.050	N.S.
Area 10	Declining	2.49^x	0.134^x	0.63^x	5.02^x	0.329^x	0.279^x	3011^x
	Healthy	2.45	0.148	1.00	4.93	0.359	0.219	1069
	$\underline{P}$	N.S.	N.S.	0.01	N.S.	0.010	0.050	0.01
Clermont, Florida								
	Declining	2.77^z	0.097^z	1.17^z	3.92^z	0.397^z	0.380^z	645^z
	Healthy	2.98	0.095	1.83	3.64	0.374	0.380	219
	$\underline{P}$	N.S.	N.S.	0.05	N.S.	N.S.	N.S.	0.01

z Mean of 5 analyses.
y Paired t-test.
x Mean of 8 analyses.

Table 3. Microelement leaf levels in declining and healthy grapefruit trees in Texas and Florida.

Location	Tree condition	Fe^z	Mn	Zn	Cu (ppm)	Cl	B	Mo
Rio Farms, Monte Alto, Texas								
Area 32	Declining	67^z	31^z	15^z	37^z	400^z	253^z	3.0^z
	Healthy	74	41	24	88	381	242	3.9
	$\underline{P}^y$	N.S.	0.01	0.02	0.01	N.S.	N.S.	N.S.
Area 10	Declining	123^x	50^x	30^x	146^x	1273^x	217^x	4.0^x
	Healthy	92	30	17	59	652	196	3.4
	$\underline{P}$	0.01	0.01	0.01	0.01	0.02	N.S.	N.S.
Clermont, Florida								
	Declining	58^z	28^z	38^z	51^z	241^z	199^z	4.2^z
	Healthy	54	19	30	55	48	161	3.1
	$\underline{P}$	N.S.	0.10	N.S.	N.S.	0.05	N.S.	N.S.

z Mean of 5 analyses.
y Paired t-test.
x Mean of 8 analyses.

DISCUSSION

Differences in leaf nutrient levels between Area 32 and Area 10 indicate that the trees in the two areas are declining from different causes. Shallow hardpans in Area 32 are the most probable cause of decline and the higher macroelement levels in the leaves of declining trees are probably due to reduced growth. The Zn level was in the deficiency range.

There are many parallels between the blight-affected trees in Florida and the declining trees in Rio Farms' Area 10. The K concentration in the leaves was lower and the Na and Cl concentrations were higher in the leaves of declining than in healthy trees; this is common with blight (1, 10). At Rio Farms, as with blight in Florida, the elements applied as leaf sprays (S, Fe, Mn, Zn, Cu) remained in the leaves of declining trees at higher levels than in the leaves of healthy trees, apparently because there was no translocation (10). There was a trend for the declining trees to take up less water than healthy trees, but there were no significant differences between the means.

There was, however, no Zn accumulation in the outer layers of the wood of declining trees. Trees on sour orange rootstock accumulate less Zn in the wood than trees on more blight-susceptible rootstocks (9), but there was no sign of accumulation in Area 10. Water-soluble phenolics in the declining trees in Area 10 were higher, as in blight trees in Florida (Table 1). It appears, therefore, that the decline in Area 10 had some similarities to blight in Florida, while the declining trees in Area 32 showed different patterns. The two key features of blight, reduced absorption of injected water and Zn accumulation in the trunk wood, were not found in the declining trees at either location in Texas. Therefore, it is unlikely that blight is the cause of the tree declines observed in Texas.

LITERATURE CITED

1. Anderson, C. A., and D. V. Calvert. 1970. Mineral composition of leaves from citrus trees affected with declines of unknown etiology. Proc. Fla. State Hort. Soc. 83:41-45.
2. Barton, C. Y. 1948. Photometric analysis of phosphate rock. Anal. Chem. 20:1068-1073.
3. Cohen, M. 1974. Diagnosis of young tree decline, blight, and sandhill decline of citrus by measurement of water uptake using gravity injection. Plant Dis. Reptr. 58:801-805.
4. Dible, W. T., E. Truog, and K. C. Berger. 1954. Boron determination in soils and plants. Anal. Chem. 26:418.
5. Lyons, C. G., Jr., and R. E. Rouse. 1979. Observations of grapefruit tree decline in Texas. J. Rio Grande Valley Hort. Soc. 33:71-74.
6. Quinn, B. F., and P. H. Woods. 1976. Rapid manual determination of sulfur and phosphorus in plant material. Comm. Soil Sci. Plant Anal. 7(4):415-426.
7. Smith, P. F., and H. J. Reitz. 1977. A review of the nature and history of citrus blight in Florida. Proc. Int. Soc. Citriculture. 3:881-884.
8. Wutscher, H. K., M. Cohen, and R. H. Young. 1977. Zinc and water-soluble phenolic levels in the wood for the diagnosis of citrus blight. Plant Dis. Reptr. 61:572-576.

9. Wutscher, H. K., H. G. Campiglia, C. Hardesty, and A. A. Salibe. 1977. Similarities between marchitamiento repentino disease in Uruguay and Argentina and blight of citrus in Florida. Proc. Fla. State Hort. Soc. 90: 81-84.
10. ________ , and C. Hardesty. 1979. Concentrations of 14 elements in tissues of blight-affected and healthy 'Valencia' orange trees. J. Amer. Soc. Hort. Sci. 104:9-11.
11. Young, R. H., H. K. Wutscher, M. Cohen, and S. M. Garnsey. 1978. Citrus blight diagnosis in several scion variety/rootstock combinations of different ages. Proc. Fla. State Hort. Soc. 91:56-59.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Evidence for the Involvement of *Diplodia natalensis* in Rio Grande Gummosis of Citrus

R. M. Davis
Assistant Professor
Texas A&I University Citrus Center
Weslaco, Texas 78596

ABSTRACT

Symptoms similar to Rio Grande gummosis (gumming, wood discoloration, and an orange band of wood) were reproduced with pure cultures of *Diplodia natalensis* P. Evans. Infections advanced through the wood of the inoculated grapefruit scion but terminated at the bud union between the scion and the sour orange rootstock. Although sour orange was susceptible to *D. natalensis*, the rootstock was rarely affected in the field. Characteristics of the budunion and/or the lack of entry points for the fungus into the rootstock were responsible for the apparent resistance of sour orange in the field. The disease was arrested in containerized citrus treated with benomyl.

Rio Grande gummosis (RGG) has been attributed to many causes. Among the various agents implicated in the disease are the fungus *Diplodia natalensis* P. Evans (6), an unidentified basidiomycetous fungus (1, 2), an actinomycete (3), and an excess of chloride salts in the soil (4). Still, the nature of RGG remains obscure partly due to the confusion in identifying disease symptoms. At least three conditions of gumming superficially resemble RGG: (i) gumming resulting from pruning or other wounds in the bark; (ii) gumming from stress, such as a rising water table, excessive salt, and mineral imbalances; and (iii) gumming typical of foot rot diseases caused by *Phytophthora* spp.

RGG discussed here is characterized by profuse gum exudation associated with wood discoloration of trunks or major limbs. Affected wood is firm and slightly darker, i.e. buff-colored, than healthy wood. The advancing margin of affected tissue is salmon to orange in color and often becomes a bright pink after exposure to the air. Collectively, these symptoms distinguish RGG from the conditions listed above.

Tissues with symptoms of RGG often spread several decimeters through the internal wood of major limbs and the trunk. Spread is faster longitudinally than laterally. Large RGG lesions may split the bark, exposing the wood to insects and wood-rotting fungi. This condition leads to the eventual necrosis of large limbs, large areas in the trunk, and sometimes the tree.

RGG in Texas has most often been attributed to *Diplodia natalensis* (6). However, this fungus has recently been discredited as the cause of RGG since sour orange, while susceptible to *D. natalensis*, is not affected when used as a rootstock in the field (4). The purpose of this study was to describe RGG symptoms in detail, identify the causal agent, and provide proof of pathogenicity.

MATERIALS AND METHODS

Orchard survey and isolations from RGG lesions. A survey of a 3.4 ha block of 25-year-old Ruby Red grapefruit (*Citrus paradisi* Macf.) trees on sour orange (*C. aurantium* L.) rootstock was made to determine the association between RGG and physical wounds in trunks and major branches. Isolations were made from 440 chips of wood cut from the margin of RGG lesions on 88 randomly selected trees within the block. Chips of wood were soaked in a 0.5% solution of sodium hypochlorite for 5 minutes, blotted dry on sterile filter paper, and aseptically transferred to petri dishes of either corn meal or V-8 juice agar. Cultures were incubated in the dark at 22 - 25° C. After 4-10 days, hyphal tips were cut from fungi growing from the chips, transferred to culture tubes of V-8 juice agar, and incubated as before to provide pure cultures for identification.

Inoculation trials. Stems at least 3 cm in diameter on 8-year-old Ruby Red grapefruit trees were inoculated with five fungi commonly isolated from RGG lesions (Tables 1 and 2). Inoculum consisted of 5 mm-diameter plugs cut from 10-day-old pure cultures on V-8 juice agar. One plug was placed in each wound made with a sterilized cork borer drilled past the cambium of the stem. Wounds were wrapped with plastic tape to prevent desiccation. Controls received sterile V-8 juice agar. Treatments were replicated 20 times. Diameter of lesions and extent of gumming were determined 90 days after inoculation.

Table 1. Fungi isolated from Rio Grande gummosis lesions on Ruby Red grapefruit trees [z].

Fungus	Number of isolations
Diplodia natalensis	122
unidentified hyphomycete	22
Phomopsis sp.	20
Colletotrichum sp.	12
Cephalosporium sp.	10
Nigaspora sp.	9
Fusarium sp.	6
Alternaria sp.	6
Chaetomium sp.	2
other	18

[z] Isolations made from 440 chips of wood cut from lesions on 88 trees from 3.4 ha of Ruby Red grapefruit on sour orange.

Table 2. Development of Rio Grande gummosis symptoms in 8-year-old Ruby Red grapefruit trees inoculated with fungi isolated from gummosis lesions.

Inoculum	No. of gummosis symptoms in 20 inoculations	Average diameter of lesions (mm)[z]	Gumming index[y]
sterile agar	0	0	0
Diplodia natalensis	18	26.3	+++
Phomopsis sp.	2	1.7	+
Collectotrichum sp.	0	0	0
Fusarium sp.	0	0	0
unidentified hyphomycete	0	0	0

[z] The diameter of the wound, 5 mm, was subtracted from the lesion diameter.
[y] Gumming index 0 = no gumming, to +++ = copious gumming.

Two-year-old Ruby Red grapefruit trees on sour orange rootstock growing in 3.5 liter containers were also inoculated with *D. natalensis*. Each of ten trees was inoculated with one plug of *D. natalensis* 10 mm above the budunion and an equal number was inoculated 10 mm below the budunion. Identical inoculations were made using chips of wood (ca. 0.25 cm) cut from RGG lesions. The inoculum included the orange-colored band of wood typical of RGG lesions. Control seedlings received either sterile V-8 juice agar or chips of healthy wood. Diameter of lesions and extent of gumming were determined 90 days after inoculation. All inoculations were made during the summer months.

Fungicide trials. Ten 2-year-old grapefruit trees on sour orange rootstock growing in 3.5 liter containers were inoculated with agar cultures of *D. natalensis* and ten were left as controls. An equal number of trees were inoculated with wood chips collected from RGG lesions. After 10 weeks, a 500 ml soil drench of benomyl (600 mg a.i./liter) was applied per pot to half of the inoculated trees. A second application of benomyl was made 2 weeks later.

RESULTS

Orchard survey and isolations from RGG lesions. Over 94% of the RGG lesions examined were directly associated with broken branches or wounds of major limbs and the trunk. Discolored wood underlying gum pockets was traceable to wounded or dead tissue. Fungi isolated from margins of RGG lesions and their frequency of isolation are listed in Table 1. *D. natalensis* was the most common fungus isolated.

Inoculation trials. Infections with symptoms typical of RGG were reproduced in the 8-year-old trees inoculated with *D. natalensis* (Table 2). Two sites inoculated with *Phomopsis* sp. exhibited gummosis symptoms, but upon isolation 90 days later *D. natalensis* and not *Phomopsis* sp. was isolated. However, slight gumming occurred in 50% of the sites inoculated with *Phomopsis*. Since no other gummosis symptoms were evident, reproduction of RGG symptoms with fungi other than *D. natalensis* was considered negative. *D. natalensis* was reisolated from 17 of the 18 lesions with positive RGG symptoms. In winter all lesions dried and activity ceased.

D. natalensis consistently caused RGG symptoms in both grapefruit and sour orange wood of the inoculated 2-year-old trees. Although gumming was profuse in both citrus cultivars, the diameters of lesions were significantly greater in grapefruit wood than in sour orange wood (Table 3). In seven of eight inoculations the advancement of the affected tissue terminated at the budunion. Two other lesions failed to reach the budunion and in one the advancing lesion passed through it. Similarly, in six of the eight inoculations where the lesion in sour orange tissue reached the budunion, the advancement of affected tissue terminated at the budunion. The lesions of the other two inoculations passed through the budunion. *D. natalensis* was reisolated from all the grapefruit tissue and from seven of eight sour orange inoculations.

Table 3. Development of Rio Grande gummosis symptoms in 2-year-old containerized Ruby Red grapefruit on sour orange rootstock inoculated with *Diplodia natalensis* or wood chips cut from gummosis lesions.

Inoculum	Part inoculated	No. of gummosis Symptoms in 10 inoculations	Average diameter of lesions (mm)[z]		Gumming index[y]
noninoculated	grapefruit[x]	0	0	a[z]	0
noninoculated	sour orange[x]	0	0	a	0
D. natalensis	grapefruit	10	19.7	c	+++
D. natalensis	sour orange	8	13.2	b	+++
Wood chips(healthy)	grapefruit	0	0	a	0
Wood chips(healthy)	sour orange	0	0	a	0
Wood chips(affected)	grapefruit	7	21.1	c	+++
Wood chips(affected)	sour orange	8	16.2	bc	++

[z] Mean separation by Duncan's multiple range test, 1% level.
[y] Gumming index 0 = no gumming, to +++ = copious gumming.
[x] Grapefruit scion and sour orange rootstock.

Grapefruit stems inoculated with chips of wood from RGG lesions exhibited symptoms typical of gummosis (Table 3). Gumming was profuse in all grapefruit inoculations and slightly less in sour orange. Control stems healed rapidly with little or no gumming. *D. natalensis* was isolated from all, except one, of the successful inoculations with affected wood chips and from none of the controls.

Fungicide trials. Drenches of soil with benomyl controlled the advancement of RGG lesions. In all trees inoculated with *D. natalensis*, gumming and advancement of lesions were stopped. All inoculations, except one, with wood chips were checked by the fungicide.

DISCUSSION

Based on the following observations, *D. natalensis* appears to be the causal agent of RGG in Texas: (i) *D. natalensis* was consistently isolated from RGG-affected tissue; (ii) symptoms of RGG developed in healthy tissue inoculated with pure cultures of *D. natalensis* and the fungus was subsequently reisolated, fulfilling Koch's postulates; (iii) the disease was transmitted with affected tissue, establishing the infectious nature of the disease; and (iv) disease development was arrested with applications of the fungicide benomyl.

The argument against the involvement of *D. natalensis* in RGG, i.e. the susceptibility of sour orange to *D. natalensis* when artificially inoculated but the apparent resistance of sour orange to RGG in the field (4), is weakened by the evidence presented here. Because RGG is directly associated with wounds, especially broken branches larger than 3 cm in diameter, it is not expected that the unbranched rootstock could be easily invaded by *D. natalensis*. Moreover, the budunion between grapefruit and sour orange can restrain the advancement of RGG. This is in agreement with Godfrey (5) and Olson (6) who also noted that the downward advancement of RGG is stopped at the budunion with the sour orange rootstock. While the sour orange appears to be resistant or even immune to RGG, the resistance is a property of the budunion and not of either the grapefruit or sour orange per se. Misinterpretation of the nature of this resistance has led to the erroneous conclusion that sour orange is immune to RGG. The mode of action of RGG termination at the budunion warrants more research.

Since most RGG lesions occur adjacent to wounds, the most important control measure is the protection of wounds with a sealant compound. Wounds resulting from freezes, diseases, insects, and mechanical injuries are likely spots for infection since *Diplodia*, a common saprophyte, is widespread and abundant in citrus orchards. The removal of dead wood would help in the control of RGG since the fungus apparently requires colonization of dead tissue to increase its inoculum potential before it can enter healthy tissue. The relationship between dead wood and the incidence of RGG needs to be determined.

ACKNOWLEDGEMENT

I thank C. F. Webster for technical assistance.

LITERATURE CITED

1. Calvan, E. C. 1961. Ferment gum disease (Rio Grande gummosis) of grapefruit. Calif. Citrog. 46:231-232.
2. __________, and D. W. Christiansen. 1958. Production of ferment gum disease in Marsh grapefruit trees by fungus inoculation. Phytopathology 48:281.

3. Childs, J. F. L. 1953. An actinomycete associated with gummosis disease of grapefruit trees. Phytopathology 43:101-103.
4. ____________. 1978. Rio Grande gummosis disease of citrus trees. Part II. The causal relations of Rio Grande gummosis. Plant Dis. Rep. 62:395-399.
5. Godfrey, G. H. 1945. A gummosis of citrus associated with wood necrosis. Science 102:130.
6. Olson, E. O., and C. W. Waibel. 1953. Rio Grande gummosis in relation to Diplodia infection in Texas citrus. J. Rio Grande Valley Hort. Soc. 7:84-94.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Leaf Reflectance-Nitrogen-Chlorophyll Relations Among Three South Texas Woody Rangeland Plant Species

H. W. Gausman, J. H. Everitt, and D. E. Escobar
Supervisory Plant Physiologist, Range Scientist, and
Biological Technician, respectively,
Soil and Water Conservation Research,
Subtropical Texas Area, Southern Region,
SEA, USDA, Weslaco, TX 78596

ABSTRACT

In spring, leaf reflectance at the 0.55-μm wavelength and nitrogen (N) concentration were high for three south Texas plant species but leaf chlorophyll (chl) concentrations were low; in summer, leaf reflectance and N concentration were low but leaf chl concentrations were high. Linear correlations for both spring and summer of leaf reflectance with N and chl concentration or deviations from linear regression were not statistically significant.

Leaf reflectance within the 0.40- to 0.75-μm waveband is influenced primarily by chlorophyll (chl) pigments (2, 3, 13). Reflectance can be used to: evaluate turf color (3), estimate the nitrogen (N) status of sweet pepper leaves (14), measure amounts of biomass or vegetation density (15, 16), and demonstrate leaf spectral and color-infrared film image differences among shrubs and woody plant species (5, 8, 9).

Leaf reflectance measurements have not been used to estimate the N or chl status of rangeland plants. A pilot study (7) indicated that leaf N concentration of six of seven rangeland species decreased as the season progressed from March to June or October. Visible light reflectance at the 0.55-μm wavelength of five of these species decreased as N concentration decreased; reflectance at this wavelength is affected by chl concentration (13). In crop plants the leaf visible light reflectance increased (decreased chl) and was inversely correlated with leaf N concentration (2, 13). This difference between rangeland and crop plants may have been caused by variation in leaf maturation or senescence (11), effects of salinity on leaf chl concentration (6), or chl may have a different dependence on leaf N content (14).

Our objective, therefore, was to make additional reflectance measurements to further evaluate their possible use to predict leaf N concentrations of three highly important south Texas rangeland woody plant species. The capability to estimate leaf N concentration using reflectance measurements would be a quick method of evaluating forage protein (N x 6.25) content, which is highly important for livestock and wildlife production.

MATERIALS AND METHODS

Three woody plant species common on south Texas rangelands, nomenclature after Correll and Johnston (4), were used in this study: Hackberry (*Celtis laevigata* Willd.), honey mesquite (*Prosopis glandulosa* Torr. var.), and live oak (*Quercus virginiana* Mill.). Hackberry is a major species on bottomland range sites. Live oak is abundant on deep sands and grows in formations ranging from dense, uniform stands to frequent thickets or motts in underbrush. Honey mesquite is a dominant species throughout the area and grows on a variety of sites (deep sands, sandy loams, clay loams, heavy clays).

Leaves of these species were collected once during spring (March) and once during summer (July) to measure their spectral reflectance and to determine their chl and N concentrations. Leaves from each of 12 trees of each species were collected from all portions of tree canopies for both spring and summer measurements. Detached leaves were thoroughly mixed and enclosed immediately in air-tight plastic bags and stored on ice to minimize dehydration during transport to the laboratory.

At each collection, two leaves from each of the 12 trees of each plant species were used to measure spectral reflectance. Total leaf chl and N concentrations (10) were determined in duplicates for each of the 12 trees of each species. The means of these measurements and determinations were used to represent each tree of each species.

Total diffuse reflectance of upper (adaxial) surface of single leaves over the 0.4 to 0.7-μm visible light waveband was measured with a Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment. (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the USDA over others that may be commercially available.) These data have been corrected for decay of the barium sulfate standard to give absolute radiometric data (1). Reflectance data given in this study are for the 0.55-μm wavelength because it is most sensitive to a change in leaf reflectance caused by a difference in pigment concentration (13).

The t-test (12) was used to test statistical differences between means of leaf N and between leaf chl concentrations for spring and summer for each of the three plant species. Linear correlations of reflectance with leaf N and chl and N with chl were calculated. Deviations from linear regression were also tested.

RESULTS AND DISCUSSION

Leaf Reflectance

The mean reflectance value for the limey-green colored leaves of the three woody plant species during spring was 16.4%. Leaf reflectance among the plant species showed that hackberry (17.6%) and mesquite (17.0%) were significantly higher than live oak (14.6%). In summer, the plant species leaves, which had become darker green, absorbed more light, thus significantly ($p = 0.01$) reducing the three species' mean reflectance value to about 8.1%--a reflectance decrease of 50.6% from spring to summer. In summer leaf reflectance of hackberry (8.0%) and mesquite (7.1%) were significantly lower than that of live oak (9.3%).

Leaf N and Chl Concentrations

Table 1 shows both spring and summer leaf N and chl concentrations of the three woody plant species. Mesquite and hackberry had 94 and 37% higher N concentration in the spring and 132 and 84% higher N concentration in the summer, respectively, than did live oak. Leaf N concentrations of hackberry, mesquite, and live oak decreased 34, 41, and 50% from spring to summer, respectively.

Table 1. The leaf nitrogen (N) and total chlorophyll (chl) concentration of the three woody plant species during the spring (March) and summer (July) of 1979.

Species	Nitrogen		Diff.	Chlorophyll		Diff.
	Spring	Summer		Summer	Spring	
	---------- % ----------			---------- Mg/g ----------		
Hackberry	3.93	2.61	1.32*	2.91	1.78	1.13*
Live Oak	2.87	1.42	1.45*	1.73	1.01	0.72*
Mesquite	5.57	3.29	2.28*	2.28	0.90	1.38*
Mean	4.12	2.44		2.31	1.23	

* Significant at the 1% probability level.

Leal chl concentration was highest for hackberry in both spring and summer. Hackberry leaves had 68 and 28% higher leaf chl concentrations than did live oak and mesquite in summer, respectively; whereas, in spring, leaf chl concentrations were 76 and 98% higher, respectively. From spring to summer, leaf chl concentrations of hackberry, mesquite, and live oak increased 63, 71, and 153%, respectively.

Leaf Reflectance vs N and Chl Concentrations

Linear correlations of reflectance with N and chl, and N with chl were not statistically significant ($p = 0.05$) for the three species in the spring, except for hackberry which had a 0.38 coefficient of determination for the correlation of reflectance with N. The other coefficients of determination were below 0.19. In summer, no correlations were statistically significant ($p = 0.05$) for any of the three woody plant species. The coefficients of determination were all below 0.31. The deviations from linear regression were not statistically significant.

The relationship between leaf reflectance and leaf N and chl concentrations, however, showed that the leaf reflectance was positively related to leaf N concentration and inversely related to leaf chl concentration. For example, during spring leaf reflectances and N concentrations were high but leaf chl concentrations were low; whereas, in summer leaf reflectances and N concentrations were low but chl concentrations were high. These findings substantiated results from our previous pilot study (7) since woody species' leaf N concentrations do not agree with crop plant results where reflectance was inversely correlated with leaf N concentration (14). However, according to our results, leaf spectral reflectance measurements cannot be used to predict leaf N concentration for woody plant species.

ACKNOWLEDGEMENT

We thank Armando Saldana for assisting with chemical analyses and R. R. Rodriguez for helping with spectrophotometric measurements.

LITERATURE CITED

1. Allen, W. A., and A. J. Richardson. 1971. Calibration of a laboratory spectrometer for specular light by means of stacked glass plates. Rev. Sci. Instr. 42:1813-1817.
2. Benedict, H. W., and R. Swidler. 1961. Nondestructive method for estimating chlorophyll content of leaves. Science. 133:2015-2016.
3. Birth, G. S., and G. R. McVey. 1968. Measuring the color of growing turf with a reflectance spectrophotometer. Agron. J. 60:640-643.
4. Correll, D. S., and M. C. Johnson. 1970. Manual of the vascular plants of Texas. Texas Research Foundation, Renner, TX. 1881 p.
5. Driscoll, R. S., and M. D. Coleman. 1974. Color for shrubs. Photogramm. Eng. 40:451-459.
6. Gausman, H. W., W. A. Allen, R. Cardenas, and R. L. Brown. 1970. Color photos, cotton leaves, and soil salinity. Photogramm. Eng. 36:454-459.
7. ____________, J. H. Everitt, and D. E. Escobar. 1979. Seasonal nitrogen concentration and reflectance of seven woody plant species. J. Rio Grande Valley Hort. Soc. 33:101-104.
8. ____________, __________, A. H. Gerbermann, and R. L. Bowen. 1977. Canopy relfectance-structure-film image relations among three south Texas rangeland plants. J. Range Manage. 30:449-450.
9. ____________, __________, ____________, and D. E. Escobar. 1976. Leaf spectral characteristics of nine woody plant species from Texas rangelands. F. Shahrokhi (ed.), Remote Sensing Earth Resources. Univ. of Tennessee, Tullahoma. 5:333-349.
10. Horwitz, W. (ed.). 1965. Official Methods of Analysis, Ed. 10, Assoc. Offic. Agric. Chemists, Washington, D.C. 957 p.
11. Salisbury, F. B., and C. Ross. 1969. Plant physiology. Wadsworth Publishing Co., Inc., Belmont, CA. 747 p.
12. Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 p.
13. Thomas, J. R., and H. W. Gausman. 1977. Leaf reflectance vs. leaf chlorophyll and carotenoid concentrations for eight crops. Agron. J. 69:799-802.
14. ___________, and G. F. Oerther. 1972. Estimating nitrogen content of sweet pepper leaves by reflectance measurements. Agron. J. 64:11-13.

15. Tucker, C. J., L. D. Miller, and R. L. Pearson. 1973. Measurements of the combined effect of green biomass, chlorophyll, and leaf water on canopy spectroreflectance of the shortgrass prairie. Remote Sensing Earth Resources. Univ. of Tennessee, Tullahoma. 2:601-626.
16. Wiegand, C. L., H. W. Gausman, J. A. Cuellar, A. H. Gerbermann, and A. J. Richardson. 1974. Vegetation density deduced from ERTS-1 MSS response. Proc.3rd ERTS-1 Symp., Vol. I, Section A, NASA SP-351, U.S. Govt. Printing Ofce., Washington, D.C. p. 93-116.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Development of Extension Demonstration Work and Scouting Techniques for Citrus Rust Mites

Leon R. Smith
Extension Agent
Pest Management - Citrus
Hidalgo-Cameron Counties

In 1979 the Texas Agricultural Extension Service initiated a program of integrated pest management (IPM) for citrus in the Lower Rio Grande Valley. This program is based on four major considerations:

1. Chemical control on an as-needed basis determined by frequent monitoring of pests and beneficial organisms.
2. Utilization of biological control agents.
3. Appropriate horticultural practices.
4. Long term cost-effectiveness.

Overall objectives are to promote greater efficiency in pest management, and to identify the most cost-effective management practice.

In developing the IPM program for citrus, the rust mite *Phyllocoptruta oleivora*, was considered the number one pest problem in the Valley. Program emphasis therefore is directed toward further study of this pest under a variety of individual management practices. Since a sound pest management program must be based on frequent monitoring to determine pest incidence and population trends, attention was focused on scouting techniques suitable for data accumulation, as well as actual pest counts. The monitoring procedure we selected utilizes the "Station Tree" concept presently used in a Florida IPM program (2), modified to meet our own specific needs and objectives.

This concept involves initial selection at random of station trees at each monitoring site: stations are then marked and numbered and the same trees are inspected continuously. This is an essential feature of the monitoring program and the only way that genuine pest population trends can be determined.

Our monitoring program this first year of operation is based on sets of ten randomly selected station trees located in each of 22 grapefruit groves dispersed mostly in the western end of the Valley (Fig. 1). Rust mite counts at each station tree are based on three lens field counts per fruit, six fruit per tree. Four fruit on the east and north sides of the tree are examined in the outer and inner canopy plus two fruit in the extreme top center. In the absence of fruit or before fruit has sized, counts are based on six leaf samples from the northeast quadrant of each station tree where mite populations are considered to be greatest (1). All counts are recorded along with available cultural data, soil moisture and other relevant observations.

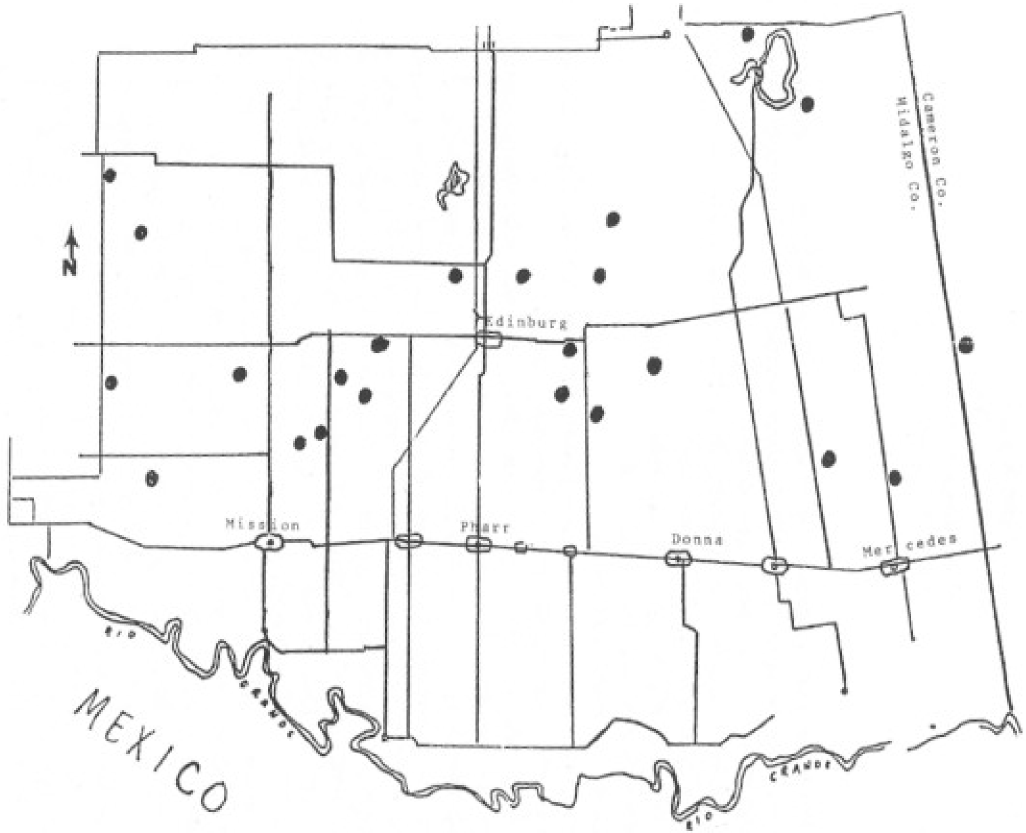

Fig. 1. Distribution of citrus monitoring sites in Hidalgo County.

Temperature and relative humidity also will be recorded continuously by hygrothermograph at two monitoring sites near Edinburg. Although the exact number of station trees required for a given acreage is not known at this time, the data obtained from each monitoring site will provide an indication of present and future pest populations and measure efficacy of pest control. In time, the assimilated data may be useful in predicting or forecasting population changes.

Most of the groves in our monitoring scheme will be subject to whatever pesticides are applied by the owner or caretaker. However, some sites involve trees that receive no pesticides but otherwise are well cared for: these trees function as reference points and permit comparison of mite and insect population dynamics between treated and untreated trees.

Another facet of the program is demonstration work in which specific materials or practices will be evaluated. Demonstrations concerned with rust mite control include three Temik® (aldicarb) sites where trees will be monitored for mites, scale insects, white-fly and citrus nematode. Two others are designed to compare performance of controlled - particle size spray equipment with conventional dilute sprayers. Another demonstration will involve a study of rust mite populations on trees sprayed periodically with a copper fungicide to observe effects of copper on a fungus parasite (*Hirsutella spp.*) and subsequent effects on mites. The fungus is widely distributed in Valley groves (3) and can readily be found on both live and dead rust mites. Its role as a biological control agent of rust mites under Valley weather conditions needs further study.

LITERATURE CITED

1. Dean, H. A. 1959. Quadrant distribution of mites on leaves of Texas grapefruit. J. Econ. Ent. 52(4):725-727.
2. Simanton, W. A. 1962. Operation of an ecological survey for Florida citrus pests. J. Econ. Ent. 55(1):105-112.
3. Villalon, B. and Dean, H. A. 1974. *Hirsutella thompsonii*, a fungal parasite of the citrus rust mite, *Phyllocoptruta oleivora* in the Rio Grande Valley of Texas. Entomophaga 19(4):431-436.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Growth and Yield Comparison of Six-Year-Old Container- and Field-Grown Red Grapefruit Trees

Norman P. Maxwell and R. E. Rouse
Associate and Assistant Professor of Horticulture, respectively
Texas Agricultural Experiment Station
Texas A&M University Agricultural Research and Extension Center
Weslaco, Texas 78596

ABSTRACT

The first 6 years' growth and productivity of container- and field-grown nursery 'Redblush' (*Citrus paradisi* Macf.) trees were determined. Fruit yield was not significantly different. Container nursery trees had a smaller mean trunk circumference than field nursery trees at the beginning and end of the experiment. Canopy volume of the field-grown trees was significantly larger than container-grown trees at the end of 6 years' growth. The smaller size of container-grown trees may offer certain advantages under current cultural practices.

Additional Index Words: citrus, container growing, nursery practices

---

Texas citrus growers have been interested in improved methods for growing nursery trees. One alternative which has recently gained popularity is growing in containers (3, 5). Published results of field performance for container-grown nursery trees are extremely limited and include only the first year of fruiting (2). Advantages of container-grown citrus trees are: a) the same site can be used indefinitely with soilless fumigated potting mixtures, b) nematodes, diseases and weeds can be avoided, c) plants are grown in a shadehouse where partial microclimate control and freeze protection are possible, and d) container-grown trees start growth faster than field-grown trees after transplanting because they have an undisturbed root system (1).

Despite the advantages with container-grown citrus trees, there has been reluctance on the part of grove owners and grove caretakers to accept their use. One primary concern is that container trees are smaller in caliper than field-grown trees at the time of orchard planting and may be delayed and/or slower coming into production. The objective of this study is to evaluate the early production years following field planting. Data are presented to evaluate the performance of container- and field-grown 'Redblush' grapefruit (*Citrus paradisi* Macf.) on sour orange rootstock (*Citrus sinensis*).

MATERIALS AND METHODS

Trees in containers were grown in 5.78 liter plastic pots containing a mixture of 1:1 (V:V) peat moss and perlite. Field nursery trees were grown 35.5 cm apart in the row. Sour orange seedlings were T-budded in April and May 1971 for field- and container-grown trees, respectively. Trees of both types were staked and headed at 46 cm. Nutrients were supplied as water soluble N-P-K supplemented with micro-nutrients for container-grown trees and as ammonium sulfate for field-grown trees. All trees were transplanted to the field in April 1972. The field-grown nursery trees were balled and burlaped for transplanting.

Soil at the planting site was Willacy fine sandy loam with a clay content of 15% to a depth of 1 m. The pH was 7.4 in the surface 15 cm. Willacy fine sandy loam is a recommended soil type for citrus in Texas.

Ten container- and ten field-grown trees were randomly selected from a two row planting of 'Redblush' grapefruit on sour orange rootstock spaced 4.6 x 7.6 m. Trunk circumference measurements were made 10 cm above the bud union in October 1972 and November 1978.

Tree volume was computed in cubic meters using the formula for oblate spheroids (6). Tree diameters were measured on the north-south and east-west axis to determine the tree mean diameter. Measurements of tree height and diameter were made in July 1978. Fruit yields were recorded in April of each year.

Cultural practices consisted of 3 to 7 irrigations (flood) per year depending upon rainfall. Weeds were controlled mechanically between rows and by contact herbicide under the trees. Trees were fertilized the first 2 years with 0.113 kg of N as ammonium sulfate per tree applied in 3 applications. The fertilizer rate was doubled for the third and subsequent years and was applied in one application during February.

RESULTS AND DISCUSSION

No significant difference in fruit yield was found in 4 of the 5 producing years (Table 1). The 1974 data was included in tabulating yields since this information is considered meaningful. There were no significant differences in cumulative or mean yields for the period studied. The mean trunk circumference of the field-grown trees was significantly larger than container trees at planting. After 6 years, the trunk circumference of field-grown trees was still significantly greater than that of the container-grown trees. In addition, canopy volume of field-grown trees was significantly greater. The difference in growth increase at the end of 6 years might indicate that the growth rate was faster for container trees. However, the growth rate (Table 2) computed by dividing the mean trunk circumference increased by the 6 years would indicate similar rates of growth. The smaller size of container-grown trees with no decrease in yield could have many advantages.

LITERATURE CITED

1. Anonymous. 1972. Potted plants: A plan for tomorrow. Citrograph 57: 435-436.
2. Leyden, R. F., and L. W. Timmer. 1978. Container production of citrus nursery stock and its performance compared to field-grown stock. J. Rio Grande Valley Hort. Soc. 32:43-53.

Table 1. Annual and cumulative fruit yield of container- and field-grown 'Redblush' grapefruit trees.

	Yield, kg						
	1974	1975	1976	1977	1978	Cum	Mean
Container trees	18.4a[z]	70.9a	81.1a	81.1a	126.6a	396.5a	79.3a
Field trees	10.2a	65.8a	107.2b	65.2a	119.7a	378.3a	75.6a

z Means separated in columns by t-test, $t_{.05} = 2.1$.

Table 2. Canopy volumes and trunk circumferences of 6-year-old Redblush grapefruit trees grown as container and field nursery stock.

	Canopy Volume,[z] (m^3)	Trunk Circumference (cm) 1972	1978	1972-78 growth rate[x]
Container grown	8.62 a[y]	4.98 a	42.22 a	6.2
Field grown	4.15 b	9.14 b	50.13 b	6.8

z Volume = $0.5236 \times d^2h$.
y Means with columns with different letters are significant at the 5% level.
x Growth rate = mean circumference increase divided by 6 years.

3. Maxwell, N. P., and C. G. Lyons. 1979. A technique for propagating container-grown citrus on sour orange rootstock in Texas. HortScience 14: 56-57.
4. Turrell, F. M. 1946. Volume of oblate spheroids. p. 144. *IN* Tables of surfaces and volumes of spheres of prolate and oblate spheroloids and spherical coefficients. University of California Press, Berkeley and Los Angeles.
5. Woods, Chuck. 1979. How the states largest nursery produces certified seed and seedlings. Florida Grower and Rancher 72(4):9-11.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Germination of Anacua Seeds

M. A. Alaniz and J. H. Everitt
Biological Technician and Range Scientist, respectively,
Soil and Water Conservation Research, Southern Region,
Science and Education Administration, Agricultural Research,
USDA, Weslaco, Texas 78596

ABSTRACT

Germination of anacua (*Ehretia anacua* (Teran & Berk.) I. M. Johnst.) seeds is restricted by an impermeable seed coat. Soaking seeds in concentrated sulfuric acid for 2 h increased germination percentage to optimum (60%). Germination was $\geq$ 46% at constant temperatures of 20 to 35°C. Percent germination was reduced by NaCl concentrations greater than 1,000 ppm in the aqueous substrate. Percent germination was reduced at -2 bars simulated moisture stress, with no germination at -10 bars tension. Germination was relatively tolerant to extreme pH values; however, at pH 12 it was significantly reduced.

Anacua (*Ehretia anacua*) [common name according to Correll and Johnston (3)], also known as sugarberry, is a native tree found on bottomland sites in central and south Texas (8). It is an evergreen in extreme south Texas but is partially deciduous in the northern parts of its geographic range.

Anacua reaches a maximum height of 15 m and has a rounded crown. The leaves are simple, dark green, rough with stiff or bristly hairs, alternate, elliptic-to-ovate shaped, and usually 3 to 6 cm long (Fig. 1). Plants generally flower in March or April, and sometimes again in September after rains. The flowers are white and fragrant and are followed by showy yellowish-orange fruit (3).

Anacua is a common tree in the Lower Rio Grande Valley of Texas. It occurs naturally in native brushy areas and is used as a shade tree in yards. The tree often becomes naturally established in yards and vacant lots, sometimes becoming a pest. Naturalization is attributed to birds eating and disseminating seeds (8).

Since little information is available on the establishment of this plant, a knowledge of its germination characteristics may be useful to horticulturists. The objectives of this experiment were to investigate the effects of simulated environmental factors on germination of anacua seeds.

MATERIALS AND METHODS

Seeds were randomly collected during summer and fall of 1978 from several populations of anacua trees in Hidalgo County, Texas. The seed pulp was removed and seeds were air-dried before storage. All seeds were stored at room conditions in 0.95-1 jars with moth balls.

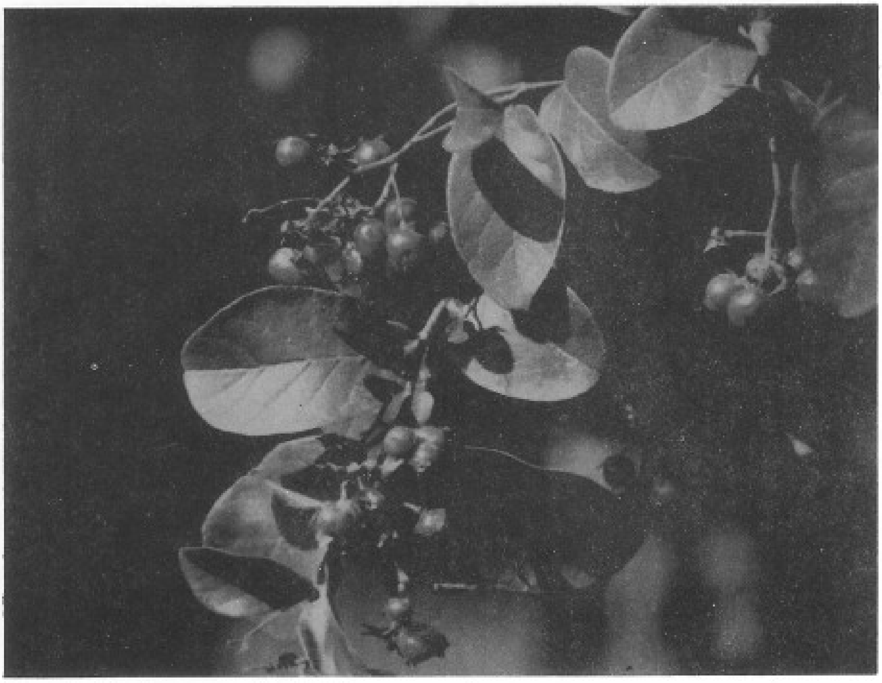

Fig. 1. The leaves and fruit of an anacua tree.

Five germination experiments were conducted in small growth chambers with automatic temperature and light controls. Unless temperature was an intended variable, experiments were conducted at a constant 30°C, using flourescent light to provide a 12-hr photoperiod. An experimental unit consisted of 20 seeds in a 9-cm petri dish containing two filter papers wetted with 15 ml of distilled water or appropriate test solution. The percent of germinated seeds was determined for each experimental unit. All experiments were designed as randomized complete blocks. Treatments were replicated five times, and each experiment was conducted twice.

Seeds were scarified by soaking in concentrated H_2SO_4 for 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 h to study the influence of the seed coat on germination (1, 6). Scarified seeds were washed with tap water and scrubbed to remove any residue. All subsequent studies conducted used seeds scarified for 2 h in H_2SO_4.

Germination of acid-scarified seeds was evaluated under temperature regimes of 10, 15, 20, 25, 30, 35, and 40°C. The petri dishes were randomized at each temperature regime.

Tolerance of anacua seeds during germination to various concentrations of NaCl was studied at a constant temperature of 30°C. Salt concentrations of 0, 250, 500, 750, 1,000, 2,500, and 5,000 ppm (wt./vol.) were formulated using distilled water.

The effects of moisture stress on seed germination were evaluated by adjusting osmotic potentials from 0 to -14 bars tension of distilled water with polyethylene glycol (PEG) 6000, using tables developed by Michel and Kaufman (5).

The influence of substrate pH on germination was investigated by adjusting the distilled water with diluted HCL or KOH (4). Germination was evaluated at pH values of 2, 3, 4, 5, 6, 7, 8, 9, 11, and 12.

Germination data were transformed (arcsin $\sqrt{\%}$) before analyzing them for variance. Differences among means were compared using Duncan's multiple range test (7).

RESULTS AND DISCUSSION

Seed germination was optimum (60%) when seeds were soaked in H_2SO_4 for 2 h (Table 1). Soaking anacua seeds 2.5 or 3.0 h significantly decreased their germination compared to 2.0 h.

Table 1. Percentage germination of anacua seeds at 30°C after a 14 day soak in sulfuric acid.

Soaking Time, h	0	0.5	1.0	1.5	2.0	2.5	3.0
Germination %	6C[z]	14C	42B	30B	60A	30B	15C

[z] Means separated by Duncan's Multiple Range Test, $p = 0.01$.

Germination percentage did not differ significantly at continuous temperatures of 20 to 35°C; however, germination was optimum at 30°C. The percent germination was lowest at 10°C (Fig. 2 Top).

NaCl concentrations up to 1,000 ppm in the aqueous substrate did not adversely affect percent germination. Increasing the NaCl concentration to 2,500 or 5,000 ppm significantly reduced germination (Fig 2 Bottom). These results in general agreed with those reported in other studies (2, 4, 6).

Percent germination of anacua seeds was significantly reduced at -2 bars, and as moisture availability decreased, germination progressively decreased (Fig. 3).

There was no significant difference in germination percentages in medias whose pH ranged from 3 to 9 (Table 2). Germination percentage of anacua seeds was significantly decreased at pH 12, but only moderately decreased at pH 2 and 11.

Although we did not conduct germination studies to investigate the influence of planting depth on anacua seeds under greenhouse conditions, our experimental tests showed that seed emergence appeared to be optimum when they were left exposed on the soil surface.

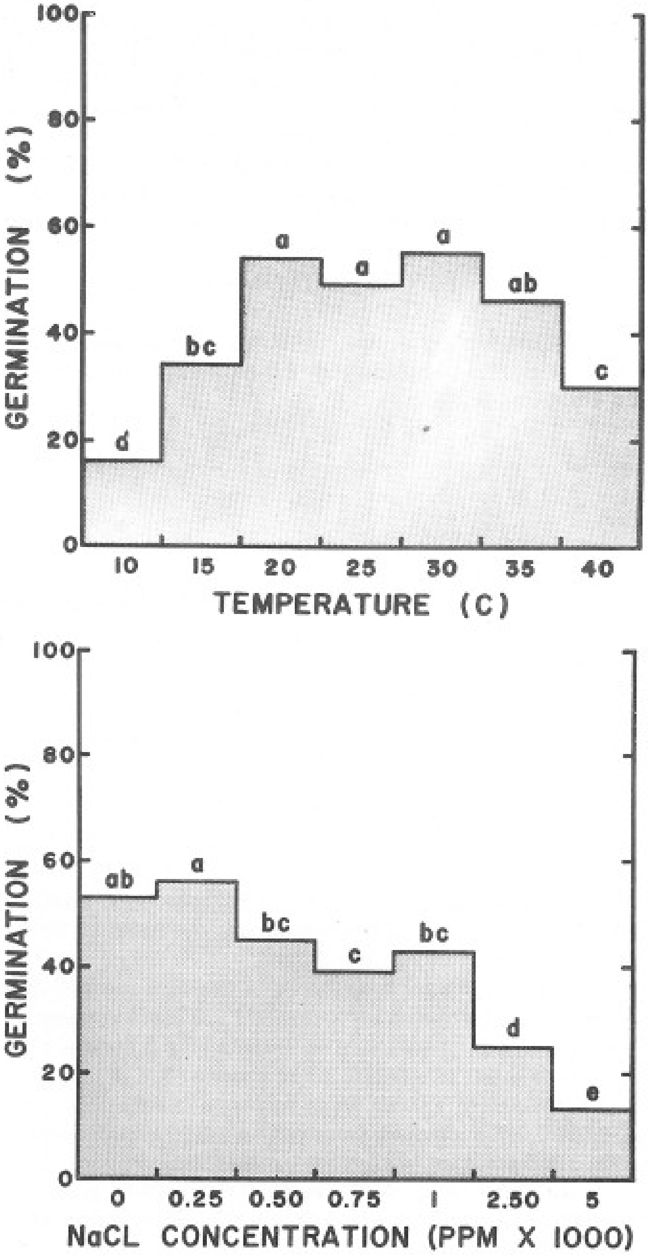

Fig. 2. Top: percentage germination of anacua seeds after a 10 day exposure to seven different temperatures. Bottom: percentage germination of anacua seeds after a 10 day exposure to various concentrations of NaCl. Plateaus designated with the same letter are not significantly different according to Duncan's Multiple Range Test, $p = 0.01$.

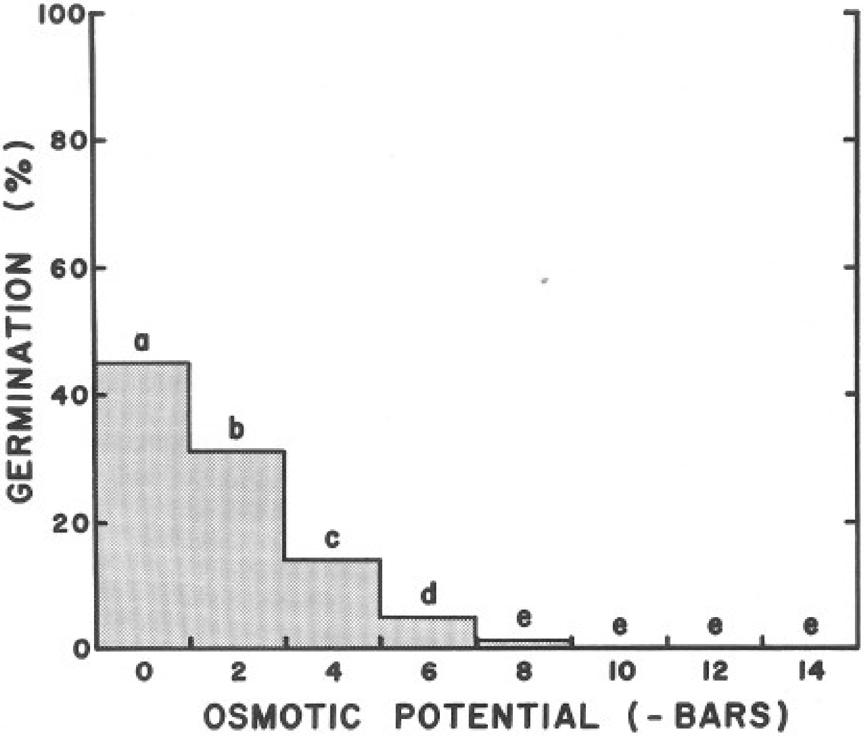

Fig. 3. Percentage germination of anacua seeds after a 10 day exposure to germination media of various osmotic potentials. Plateaus designated with the same letter are not significantly different according to Duncan's Multiple Range Test, p = 0.01.

Table 2. Percentage germination of anacua seeds after a 10 day exposure to solutions of various pH values.

pH	2	3	4	5	6	7	8	9	11	12
Germination %	29B[z]	38AB	46A	48A	50A	51A	45A	49A	26B	11C

[z] Means separated by Duncan's Multiple Range Test, p = 0.01.

ACKNOWLEDGEMENT

We thank Fernando Martinez, Jr., for his assistance in the laboratory.

LITERATURE CITED

1. Alaniz, M. A. and J. H. Everitt. 1978. Germination of Texas ebony seeds. J. Rio Grande Valley Hort. Soc. 32:95-100.
2. Ayers, A. D. 1952. Seed germination as influenced by soil moisture and salinity. Agron. J. 44:82-87.
3. Correll, D. S. and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Tex. Res. Found., Renner, Texas. 1,881 p.
4. Mayeux, H. S., Jr. and C. J. Scifres. 1978. Germination of goldenweed seed. J. Range Manage. 31:371-374.
5. Michel, B. E. and M. R. Kaufman. 1973. The osmotic potential of polyethylene glycol 6000. Plant Physiol. 51:914-916.
6. Scifres, C. J. 1974. Salient aspects of huisache seed germination. Southwest. Nat. 18:383-392.
7. Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 p.
8. Vines, R. A. 1960. Trees, shrubs, and woody vines of the southwest. Univ. Tex. Press, Austin. 1,104 p.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Evaluation of Controlled Release Nitrogen Fertilizers on Cabbage and Onions

R. P. Wiedenfeld
Assistant Professor, Soil Science
Texas Agricultural Experiment Station
Weslaco, Texas 78596

ABSTRACT

Several experimental controlled release nitrogen (N) fertilizers were evaluated and compared with conventional N fertilizer on cabbage (*Brassica oleracea* var. *capitata)* and onions (*Allium cepa*) in the Lower Rio Grande Valley of Texas. Soil analysis shows that elevated soil N levels after 3½ months occur only where delayed fertilizer applications have been made. N contents of both crops were proportional to inorganic soil N levels during early plant development. Highest yields from cabbage were obtained where the highest rates of N were applied preplant regardless of fertilizer release pattern. Highest onion yields were obtained from treatments causing delayed N availability, with slow release fertilizers causing larger onion size.

Nitrogen (N) frequently is a limiting factor in vegetable crop production. Use efficiency of fertilizer N is often low due to various losses which cause considerable waste. Conventional soluble fertilizers are applied to vegetable crops in excessive quantities or at frequent intervals to compensate for such losses. Controlled release N fertilizers reduce N losses while providing a continuous supply of N to the crop. The efficiency of controlled release materials as a N source has been demonstrated for a variety of crops and soils (1).

Evaluations of slow release N materials have indicated that they may be of some benefit in the Lower Rio Grande Valley (2, 3). After soil leaching, coated NH_4NO_3 improved forage yields in greenhouse studies over a non-coated NH_4NO_3. The coated material also decreased leaching losses where cabbage was grown under field conditions (2). Materials similar to those used in this study have been evaluated on cantaloupes and bell peppers (3). Though yield responses were not shown, the slow release materials improved N availability which could be of benefit under some circumstances.

Both cabbage and onions are long season winter crops in South Texas and require high nitrogen levels. Excessive winter rainfall makes supplemental N necessary when a soluble N fertilizer is applied preplant. Supplemental fertilizer applications are difficult when fields are wet and inaccurate fertilizer placement may result in injury to sensitive root systems.

This study evaluated a methylene urea (MU) compound in which the N is held in a complex chemical structure, and two sulfur coated ureas (SCU) on cabbage and onions. These slow release fertilizers were compared to ammonium sulfate (AS) for yield, N uptake and N transformations in the soil.

MATERIALS AND METHODS

Field studies were conducted during the winter of 1979-80 at the Texas A&M University Agricultural Research and Extension Center at Weslaco on a sandy clay loam soil. Fertilizer treatments were replicated five times in randomized block designs. Yellow onions (Texas Grano 502) and cabbage (Hybrid Snibel) were planted double row in plots of three 40 inch wide rows, 24 feet long on October 19. Nitrogen was applied as one of the experimental controlled release fertilizers (Table 1) or as soluble ammonium sulfate (21-0-0) with different placements and timings. Cabbages were thinned to 8 inches and onions to 3 inches in December. Split fertilizer applications were made in late fall and early spring. On cabbage the prescribed rates were divided into equal parts for each application while on the onions 1/3 of the prescribed rate was applied in the first, and 2/3 in the second application. A total of 7 irrigations were required for both crops.

Table 1. Fertilizers used in this study.

Abbreviation Used	Fertilizer	N Content	Release Pattern
		%	
AS	Ammonium sulfate	21	100% Soluble N
MU	Methylene urea	39	38% water insoluble N
SCU-3	Sulfur coated urea	37	3 month release
SCU-4	Sulfur coated urea	36	4 month release

Prior to any fertilizer applications in the fall, and again 3¼ months later on January 28, soil samples were taken with a hand probe in the center of the bed 12 inches deep. These soil samples were analyzed for NH_4^+- and NO_3^--N by the Kjeldahl method.

Leaf samples were taken from the youngest mature leaves on January 10 for onions and February 19 for cabbage. Total N was determined by wet digestion in sulfuric-salicylic acid and the Kjeldahl method.

Yield was determined by harvesting one row from each plot. Onions were separated in various size groups from one harvest on May 6, while cabbage was harvested several times as head matured from March 6 to April 11.

RESULTS AND DISCUSSION

Soil N levels were low in the fall (October) when these studies were initiated, averaging less than 10 PPM total inorganic N. Soil N levels in January (3½ months later) for both crops were erratic, but somewhat related to the application rate and time since application (Table 2). For cabbage, preplant MU or the MU plus AS combination showed soil N levels no greater than the unfertilized check. The preplant SCU's and AS had somewhat higher soil N, while the split AS and thinning MU or MU plus AS had much higher soil N levels. For onions, only the split applications of AS showed soil N levels greater than the rest of the preplant or unfertilized treatments. In contrast to soil N levels measured during the summer months (3), a higher proportion of the N was usually found in the NH_4^+ form than in the NO_3^- form, thus indicating a decrease in the nitrification process during cooler seasons.

Plant tissue nitrogen levels were generally related to the rate of available N during early plant development (Table 3). Thus, highest plant tissue N levels were found where the high rates of fertilizer were applied preplant, regardless of release pattern. For cabbage, a crop with a very high N requirement, all fertilizer treatments showed plant tissue N significantly greater than the unfertilized check. For onions, delayed split applications of ammonium sulfate, and lower rates of preplant slow release fertilizer showed plant tissue N levels not significantly different from the unfertilized check.

Cabbage yields fell into two distinct groups (Table 4). All treatments receiving 150 lbs N/A preplant, regardless of release pattern or placement, yielded significantly more than any of the other treatments. Later applications at 150 and 240 lbs N/A gave lower yields. Cabbage yield thus seems to respond to available N during early plant development. Rainfall during the growing period was only 5.3 inches. During such low rainfall N losses would not be excessive, reducing the potential benefit of a slow release fertilizer.

Onion yields showed interesting differences between treatments, both in total weight and in distribution among size classes (Table 5). Unlike plant tissue N content, total yield was high when the fertilizer application provided high N levels later during plant development. Yields were lowest when soluble ammonium sulfate was applied preplant. Split applications of ammonium sulfate, and various applications of slow release fertilizer gave highest yields. Among the higher yielding treatments, slow release fertilizer showed considerable advantage over split ammonium sulfate applications in the percentage of onions which fell into the largest size class. Fertilizer placement, whether broadcast or banded in the center or the shoulders, had little effect on onion yield.

Extended N availability by slow release fertilizers was not readily apparent from soil analysis. Reduced plant tissue N levels where slow release fertilizers were applied compared to similar rates of soluble AS indicate that at least some of the N is being held against immediate release. The N released immediately is adequate to produce optimum yields in cabbage where early N availability is required. The delayed N availability of the slow release fertilizers caused onion yields comparable to split applications of soluble AS, and in some cases showed improvements in onion size distributions. The benefit of this extended availability depends largely on uncontrollable factors including climate. Conditions

Table 2. Soil nitrogen levels under cabbage and onions following various ferlizer applications.

	Cabbage					Onions				
	Treatment					Treatment				
Date	Rate	Material	Application	NH_4^+-N	NO_3^--N	Rate	Material	Application	NH_4^+-N	NO_3^--N
	lbs N/A			ppm		lbs N/A			ppm	
10/15/79				3.9[2]	5.7				3.7	6.0
1/28/80	0			5.3	5.0	0			4.2	5.0
	150	AS	Split[1]	87.1	13.5	60	AS	Split-banded	21.0	21.9
	240	AS	Split	284.1	10.9	120	AS	Split-banded	53.0	31.4
	150	AS	Preplant	33.1	10.2	60	AS	Preplant-broadcast	4.8	6.7
	100	MU	Preplant	5.0	7.0	120	AS	Preplant-broadcast	3.4	11.7
	50	AS								
	100	MU	Preplant	3.9	5.9	60	MU	Preplant-broadcast	4.2	6.7
	150	MU	Preplant	4.2	5.6	120	MU	Preplant-broadcast	4.8	12.3
	150	MU	Preplant-broadcast	3.8	6.2	120	MU	Preplant-banded shoulders	3.6	10.1
	150	SCU-3	Preplant	10.1	6.2	120	MU	Preplant banded in center	4.2	9.8
	150	SCU-4	Preplant	24.7	11.2	60	MU	Preplant-broadcast		
						60	AS	Spring-banded	3.1	7.9
	100	MU	Thinning	120.5	21.6	120	SCU-3	Preplant-broadcast	3.1	12.2
	50	AS								
	150	MU	Thinning	103.9	20.9	120	SCU-4	Preplant-broadcast	4.2	14.6

[1] Fertilizer materials were applied in double bands 6" below and to both sides of the plant rows, except where indicated otherwise.

[2] Preplant values are means of duplicate analyses on each of 10 samples taken randomly from study site. Winter values are means of duplicate analyses on composite samples derived from all five reps of each treatment.

Table 3. Cabbage and onion nitrogen content following various fertilizer applications.

Cabbage				Onions			
Treatment			Leaf Nitrogen	Treatment			Leaf Nitrogen
Rate	Material	Application		Rate	Material	Application	
lbs N/A			%	lbs N/A			%
0			1.62 a[y]	0			2.32 a
150	AS	Split[z]	2.17 bc	60	AS	Split banded	2.34 a
240	AS	Split	2.21 bcd	120	AS	Split banded	2.44 ab
150	AS	Preplant	2.70 e	60	AS	Preplant-broadcast	2.85 cde
100	MU	Preplant	2.40 cde	120	AS	Preplant-broadcast	3.12 ef
50	AS						
100	MU	Preplant	2.17 bc	60	MU	Preplant-broadcast	2.59 abcd
150	MU	Preplant	2.56 de	120	MU	Preplant-broadcast	2.98 def
150	MU	Preplant-broadcast	2.20 bcd	120	MU	Preplant-banded	
						in shoulder	2.83 cde
150	SCU-3	Preplant	2.54 cde	120	MU	Preplant-banded	2.91 cdef
						in center	
150	SCU-4	Preplant	2.42 cde	60	MU	Preplant-broadcast	
				60	AS	Spring-banded	2.55 abc
100	MU	Thinning	2.49 cde	120	SCU-3	Preplant-broadcast	2.81 bcde
50	AS						
150	MU	Thinning	1.98 b	120	SCU-4	Preplant-broadcast	3.28 f

[z] Fertilizer materials were applied in double bands 6" below and to both sides of the plant rows, except where indicated otherwise.
[y] Means in each column followed by the same letter are not statistically different at the 10% significance level using Duncan's multiple range test.

Table 4. Cabbage yield following various fertilizer applications.

Treatment			Yield
Rate	Material	Application	
lbs N/A			Tons
0			6.80 a[y]
150	AS	Split[z]	8.72 a
240	AS	Split	7.73 a
150	AS	Preplant	15.51 b
100	MU	Preplant	15.49 b
50	AS		
100	MU	Preplant	9.11 a
150	MU	Preplant	15.62 b
150	MU	Preplant-broadcast	16.76 b
150	SCU-3	Preplant	14.38 b
150	SCU-4	Preplant	13.92 b
100	MU	Thinning	7.27 a
50	AS		
150	MU	Thinning	7.84 a

[z] Fertilizer materials were applied in double bands 6" below and to both sides of the plant rows, except where indicated otherwise.

[y] Means followed by the same letter are not statistically different at the 10% significance level according to Duncan's multiple range test.

Table 5. Onion yield following various fertilizer applications.

Treatment			Yield			
			Size Classes			Total Weight
Rate	Material	Application	>3"	2-3"	<2"	
lbs N/A				%		Tons/A
0			2	70	28	8.73 a[z]
60	AS	Split-banded	17	73	10	13.68 bcd
120	AS	Split-banded	7	83	9	13.08 bcd
60	AS	Preplant-broadcast	29	60	11	11.88 bc
120	AS	Preplant-broadcast	37	58	5	10.71 ab
60	MU	Preplant-broadcast	13	76	11	11.88 bc
120	MU	Preplant-broadcast	35	59	6	16.13 d
120	MU	Preplant-banded in shoulder	19	72	9	13.35 bcd
120	MU	Preplant-banded in center	28	54	18	14.61 cd
60	MU	Preplant-broadcast	21	69	10	12.48 bc
60	AS	Spring-banded				
120	SCU-3	Preplant-broadcast	26	64	10	13.18 bcd
120	SCU-4	Preplant-broadcast	42	54	4	13.20 bcd

[z] Means followed by the same letter are not statistically different at the 10% significance level according to Duncan's multiple range test.

that promote N losses would cause the benefit of slow release fertilizers to be more apparent.

ACKNOWLEDGEMENT

This study was partially funded by O. M. Scott & Sons Company, Marysville, Ohio.

LITERATURE CITED

1. Hauck, R. D. and M. Koshino. 1971. Slow-release and amended fertilizers. p. 455-494. In R. A. Olsen (ed.-in-chief). Fertilizer technology and use. Soil Sci. Soc. Amer. Inc., Madison, Wis.
2. Heilman, M. D., J. R. Thomas and L. N. Namken. 1966. Reduction of nitrogen losses under irrigation by coating fertilizer granules. Agron. J. 58:77-80.
3. Wiedenfeld, R. P. 1979. Evaluation of controlled release nitrogen fertilizers on cantaloupes and bell peppers. J. Rio Grande Valley Hort. Soc. 33:29-36.

Lethal Decline of *Phoenix canariensis* and *P. dactylifera* in the Rio Grande Valley

M. E. Miller, N. P. Maxwell and J. Amador
Assistant Professor and Associate Professor,
Texas Agricultural Experiment Station and
Area Plant Pathologist
Texas Agricultural Extension Service
Weslaco, Texas 78596

ABSTRACT

A rapid spreading disease of *Phoenix canariensis* Chaub. and *P. dactylifera* L., Canary Island date and true date palms, respectively, has been detected in the Lower Rio Grande Valley of Texas. The similarity of symptoms, pattern of spread, list of susceptible and resistant palms and presence of mycoplasmalike organisms in the phloem sieve elements indicate that this disease is identical or very similar to a disease of palms in Florida known as lethal yellowing or lethal decline.

A rapid spreading lethal decline of *Phoenix canariensis* Chaub., and *P. dactylifera* L., Canary Island date and true date palms, respectively, was detected in the Brownsville, Texas area in mid-1978. By late 1980 diseased palms were observed approximately forty miles westward in the Harlingen-La Feria area. In Brownsville where the disease was first observed, large numbers of the *P. canariensis* have been killed. *P. canariensis* and *P. dactylifera* currently are the only palms in the Rio Grande Valley found to be affected by this disease (Fig. 1). *P. canariensis* is the most widespread of the two palm species, growing along many of the roadways; *P. dactylifera*, on the other hand, is found only in a few scattered plantings.

The disease is caused by mycoplasmalike organisms in the phloem sieve elements of the palms (6). The similarity of symptoms, pattern of spread, list of susceptible and resistant palms and presence of mycoplasmalike organisms in the phloem sieve elements indicate that this disease is identical or very similar to a disease of palms in Florida known as lethal yellowing or lethal decline.

SYMPTOMS OF LETHAL DECLINE

It is difficult to diagnose lethal decline on any one given symptom. Instead, a combination of symptom expressions should be used when diagnosing this disease. The progression of symptom expressions generally takes 3 - 5 months from the time the first symptom is noticed until the death of the palm. Progression of symptom expression can be grouped into the following four stages.

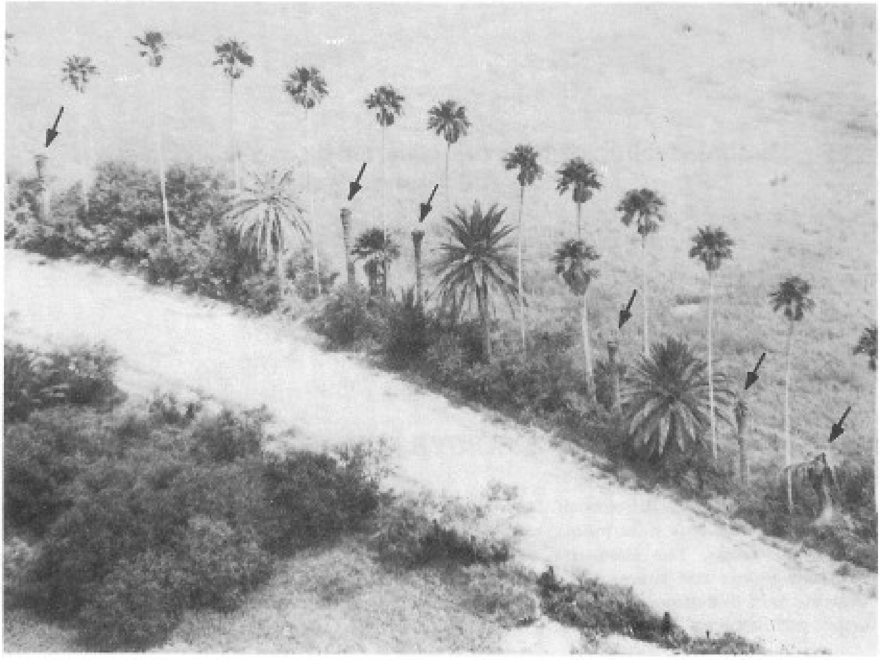

Fig. 1. Trunks of *Phoenix canariensis* (arrows), killed by lethal decline, standing next to resistant *Washingtonia robusta* in the Brownsville area.

Stage 1: The first noticeable symptom is the death of the center flag leaf. A soft rot caused by secondary organisms will occur at the base of the flag leaf; in many cases this leaf can easily be pulled from the crown. Because of the dense canopy, the absence of other symptoms and the height of the mature palms, this symptom expression can be easily overlooked. On bearing date palms, the dates will drop prematurely and the immature inflorescences will be necrotic. Palms have to be dissected to observe the latter symptom since in many cases the necrotic inflorescence will not expand from its spathe. Adventitious roots at the base of the trunk will begin to die, with the roots of diseased palms appearing brown as opposed to the cream-colored to white appearance of healthy roots.

Stage 2: A dull gray shade of green will be noticed on the leaves, as opposed to a dark green coloration on healthy palms. The lowest leaves in the crown will begin to turn brown and desiccate (Fig. 2).

Stage 3: The browning of the leaves will progress upward in the crown and the lower leaves will begin to droop and die until only the topmost leaves are still erect (Fig. 3). The soft rot in the bud tissue will be advanced at this time and will have a pronounced offensive odor.

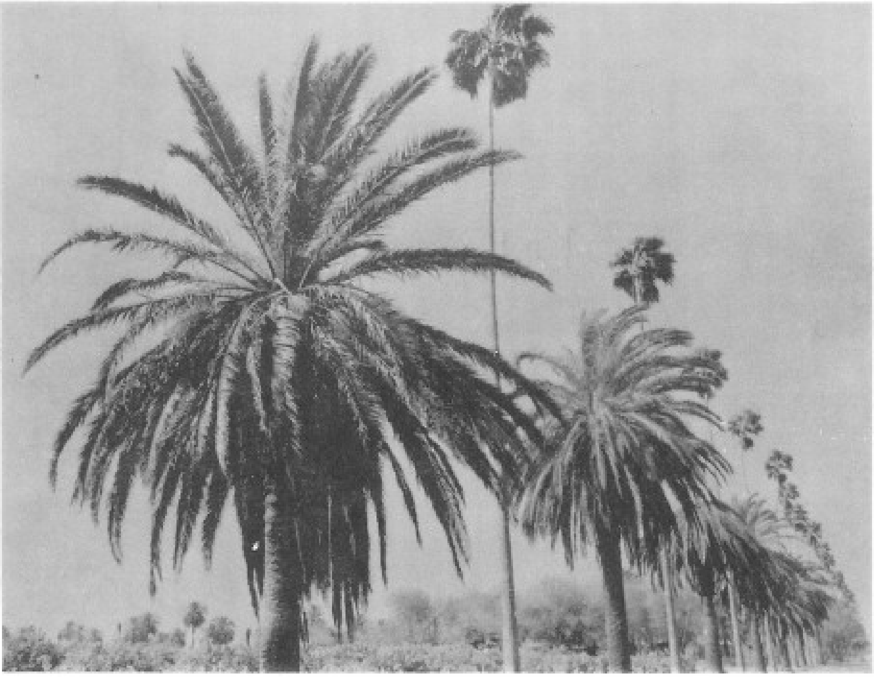

Fig. 2. *Phoenix canariensis* in foreground exhibiting drooping of lower leaves typical of early symptoms of lethal decline.

Stage 4: The remainder of the leaves in the crown will turn brown and begin to droop. Eventually, the entire crown will fall, leaving only a bare trunk.

HISTORY OF LETHAL DECLINE

The first recorded report of lethal yellowing or lethal decline was by Fawcett in 1891 on coconut palms, *Cocos nucifera* L., near Montego Bay, Jamaica (2). Subsequently, the disease has been reported throughout the Carribbean Islands and Florida and is probably identical to the Kaincope disease of coconut palms in Togo, West Africa (4). This disease has decimated plantings of susceptible palms wherever it has occurred. Lethal yellowing was identified in Key West, Florida in 1958 and within thirteen years approximately three-fourths of the 20,000 coconut palms on the island had been killed. The disease appeared in Miami, Florida in 1971 and killed more than eighty percent of the 350,000 coconut palms in the greater Miami area within 4½ years (4). The disease continues to spread in the South Florida area.

For many years the disease was believed to be confined to the coconut palm. After the outbreak of lethal yellowing on the Florida mainland, numerous *Vetchia merrillii* (Becc.) H. E. Moore, Christmas palm, and *Pritchardia* spp. palms declined and died in areas of heavy lethal yellowing infection. Mycoplasmalike organisms were also found in the phloem of these palms. Since that

Fig. 3. *Phoenix canariensis* exhibiting final symptoms of lethal decline. The entire crown will fall in a matter of weeks, leaving only the trunk standing.

time, mycoplasmalike organisms have been found in the phloem of twenty-three palm species that were exhibiting declining symptoms (8). The term lethal decline was introduced for mycoplasmalike-associated diseases in palms other than coconut, although it is thought that these diseases are identical (8).

CONTROL

Several measures have been applied to control the spread of the pathogen within infected areas and to prevent spread to remote geographic areas. To reduce the spread within infected areas the following measures have been utilized; (1) quarantines, (2) destruction of infected trees, (3) treatments with oxytetracycline hydrochloride and (4) resistant varieties.

Quarantines:

Quarantines have been used against lethal yellowing for many years and have undoubtedly helped to restrict the movement of the disease from one area to another. The effectiveness of lethal yellowing quarantines depends on several factors, with the more important being the willingness and ability of the regulatory agencies to enforce the quarantine laws and the willingness of the public to live within the guidelines of the quarantine.

After lethal decline (lethal yellowing) had been identified in the Rio Grande Valley, an emergency quarantine was enacted to prevent the movement of *P. canariensis* and *P. dactylifera* within and from Cameron, Hidalgo and Willacy counties except by special permit issued by the Texas Department of Agriculture. A permanent quarantine was enacted in May, 1980. Although this quarantine will not prevent the movement of the causal agent of lethal decline within these three counties, hopefully it will prevent its movement to other areas of Texas and other states that have populations of susceptible palms.

Removal of Infected Palms:

Attempts to contain the spread of lethal yellowing by removal of infected palms did not stop the spread of the disease in Florida (4). Although removal of infected palms is not expected to contain the spread of the pathogen in Texas, infected trees should be removed since the dead trunks present an unsightly appearance.

Treatments with Oxytetracyclines:

Oxytetracycline hydrochloride has been used to control lethal decline of *Cocos nucifera* and *Pritchardia* spp. in Florida with some success. Palms will exhibit remission of symptoms when treated with three grams (active ingredient) of tetracycline every four months; however, if the treatments are discontinued the palm will again exhibit symptoms of the disease and will die within approximately four months. The rate of spread of lethal yellowing can be reduced 3-5 times when healthy palms within a disease focus are injected with 1-3 g oxytetracycline every four months (5). Oxytetracycline is the only treatment that has been proven to be effective against lethal decline.

Recently this treatment was cleared for use against lethal decline in Texas. The Texas Department of Agriculture has approved a Section 24(c) registration of Terramycin tree injection formula (oxytetracycline hydrochloride) for use on *P. canariensis* and *P. dactylifera* in Texas.

Resistant Varieties:

A list of palm species resistant and susceptible to lethal decline in Florida was checked to determine varieties that can be recommended for highway, streets and backyard plantings in the Valley.

Several palm species are used in the Rio Grande Valley that are currently reported as either immune or highly tolerant to the mycoplasmalike organism. A description of these and others that might be considered for planting is listed below. Botanical descriptions were obtained from Palms of the World (7) and Palms for Texas Landscapes (1).

1. Fan Palms

a) *Washingtonia robusta* - A cold-hardy fan palm native to northwest Mexico that is currently being used for both highway and street planting in the Rio Grande Valley. The palms are fast growing, attain a height of up to 80 feet and will survive with a minimum amount of care. Leaves adhere to the trunk for many years if not pruned and form a petticoat of dead leaves. The persistent leaves are quite distinctive, but are a fire hazard. *W. robusta* is cold hardy enough to be grown in areas where the minimum temperatures are above 15°F.

b) *Washingtonia filifera* - The petticoat palm is native to southern California, western Arizona and northwestern Mexico. This cold hardy fan palm is similar to *W. robusta* but differs from it in several obvious characteristics. Its maximum height is about 50 feet, the trunk is thicker (3 feet diameter) and not enlarged at the base, the trunk color is gray instead of brown and the leaf color is gray green instead of bright green. *W. filifera* is considered slightly cold hardier than *W. robusta* and can be grown where minimum winter temperatures are above 15°F. It is used to some extent in the Rio Grande Valley for highway and avenue planting but not as much as *W. robusta*.

c) *Sabal texana* - This palm is native to the extreme southern part of Cameron County near Brownsville. The palm is very cold hardy and rather slow growing but eventually will make an attractive palm for either highway or backyard plantings. The Sabal palm is used in landscapings north of the Valley, particularly around Uvalde, San Antonio and as far north as Dallas and Fort Worth. The palm grows to a height of 50 feet with a trunk up to 24 inches in diameter. The palmate leaves are gray green in color with smooth petioles.

d) *Rhapis excelsa* - The Lady palm has multiple cane-like trunks. It is best adapted to shady areas and grows rather slowly. This palm can be recommended as a specimen plant for backyards in the Rio Grande Valley.

e) *Erythea armata* - The blue fan palm or blue Hesper palm is a slow growing fan palm that is well adapted to the Valley. The leaves are stiff and upright with a bluish-gray color and a powdery bloom on both surfaces. The palm is useful as a specimen plant for backyard plantings where temperatures are above 20°F.

2. Pinnate Leafed Palms

a) *Arecastrum romanzoffianum (Cocus plumosa).* The Queen palm is native to central and southern Brazil. The palm attains a height of 25-35 feet and the smooth gray ringed trunk is about 1-2 feet in diameter. The pinnate leaves are 8-15 feet long and bright green colored. The Queen palm is adapted to the Rio Grande Valley and can be used for street planting or yard specimens. This palm is only cold hardy to 25°F, therefore should only be used in town or where there is some cold protection. Some chlorosis may be experienced with this palm on alkaline soils.

b) *Butia capitata* - The Pindo or Jelly palm is quite attractive with arching blue green pinnate-leafed fronds. It is slow growing with a heavy trunk and reaches a height of 4-10 feet. It is useful as a specimen for home landscaping. The Jelly palm is extremely cold hardy and can be planted as far north as Dallas and is also grown on the east coast in North and South Carolina.

c) *Phoenix roebelenii* - The pigmy date palm is a small, slow growing ornamental palm that can be grown as a pot plant or outdoors in the shade where temperatures are above 20°F. The pinnate leaves grow to about 30-40 inches long under Rio Grande Valley growing conditions. The bright green leaves have slender weak spines near the base. The fruit are about 1/2 inch long and resemble small dates.

LITERATURE CITED

1. Dewers, R. S. and T. L. Keeter. 1972. Palms for Texas Landscape. Texas Agric. Progress Vol. 18, No. 1, pp. 20-22.

2. Fawcett, W. 1891. Report on the coconut disease at Montego Bay. Bull. 23, Bot. Dept. of Jamaica.
3. McCoy, R. E. 1974. How to treat your palm with antibiotic. Univ. of Fla. Agric. Exp. Sta. Cir. 5-228. 7 pp.
4. ———— 1976. Comparative epidemiology of the lethal yellowing, kaincope and cadang-cadang diseases of coconut palm. Plant Dis. Rep. 60: 498-502.
5. ————, V. J. Carroll, C. P. Poucher and G. H. Gwin. 1976. Field control of coconut lethal yellowing with oxytetracycline hydrochloride. Phytopathology 66:1148-1150.
6. ————, M. E. Miller and D. S. Williams. 1980. Lethal yellowing strikes Texas Phoenix palms. Principes, J. of the Palm Soc. 24 (In Press).
7. McCurrach, J. C. 1960. Palms of the world. Harper & Brothers, N. Y. 290 pp.
8. Thomas, D. L. 1979. Mycoplasmalike bodies associated with lethal declines of palms in Florida. Phytopathology 69:928-934.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Float Diameter Influence on FW-1 Recorder Accuracy

S. R. Vangsnes and N. H. Welch
Engineering Technician and Soil Scientist, respectively,
Soil and Water Conservation Research,
Subtropical Texas Area, Southern Region,
SEA, USDA, Weslaco, TX 78596
and
Southern Plains Watershed Research,
Oklahoma-Texas Area, Southern Region,
SEA, USDA, Chickasha, OK 73018

ABSTRACT

Floats of many sizes are used to sense the change in water level in streams, canals, reservoirs and wells. Float diameters of 3, 5, 6 (heavy weight), 6 (light wieght), and 10 inches were studied to determine the effects of float size in performance of water level recording instruments. The basic experimental design was a 5 x 5 latin square with floats assigned as treatments, run or replications assigned as rows, and recorders assigned as columns. Differences in error among floats, run, and recorders were not great enough to be statistically significant at the 5% level. Differences among floats were significant at the 10% level but varied among floats at the different rise and fall rates investigated. Based on this experimentation, the authors prefer the 3 inch float because of satisfactory performance and lower cost, 5-inch, 10-inch, 6-inch light, and 6-inch heavy, in that order.

Additional index words: Flow measurement, Measuring instruments, Water, Waterstage accuracy, Instrumentation costs

---

Flow rates and laboratory installations and changes in storage in reservoirs are monitored by recording the water level in an observation well connected to the water body. Floats of many sizes are used to sense the change in water level in the wells. Theoretically, larger floats should be more sensitive because they provide a greater displacement per elemental change in water level. The displacement is directly proportional to the area of the float; therefore, a 6-inch float should be 4 times as sensitive as a 3-inch float. One would also expect heavier floats to be more stable. However, experience has indicated that float weight and size may not be significant. Since the cost of an installation is directly proportional to the size of the float well, information on the performance of various size floats would be useful.

The objective of this study was to determine the effects of float size on water level recording systems. Floats of several different sizes were evaluated. As float performance is a function of the rise characteristics and the recorder to which it is connected, i.e., internal friction of recorders is not the same, the experiment was designed as a latin square to incorporate all three variables.

PROCEDURE

Five Belfort FW-1 recorders (1), each with one float and the recommended counterweight attached were placed over a tank with a separate compartment for each float. (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the USDA over others that may be commercially available.) These compartments allowed water to move freely throughout the tank. Water was supplied by a perforated pipe along the bottom of the tank. Float diameters of 3, 5, 6 (heavy weight), 6 (light weight), and 10 inches were selected to evaluate the effect of float size on observed water level (Table 1). Two 6-inch floats of different weight were included to obtain information on the influence of float weight. The recorders were carefully checked for zero, traverse, reversal, and horizontal line movement. Six-hour time gears were used with a 5:12 gear ratio on the float wheel. With this gear arrangement, the chart made one revolution in 6 hours, and 5 inches vertically on the chart represented 1 ft change in water level.

Table 1. Diameter, weight, and recommended counterweight for each float used in the test.

Float		
Diameter	Weight	Counterweight
Inches	Ounces	Ounces
3	8	3
5	18	6
6-L	26	8
6-H	30	8
10	56	12

Reference for above:
Leupold Stevens, Inc.,
Stevens Instrumentation for Hydrology and Meteorology,
A-35 Recorder Instruction Book, Form A-370.

Five runs were made, with each run consisting of four 30-minute periods with different rates of rise and fall. Rise rates of flow were 2.80 ft/h and 0.50 ft/h, followed by fall rates of 0.90 ft/h and 1.70 ft/h. After each run, each float was switched to a different recorder. Thus, each float was tested on each recorder. During each of the five runs, numerous point gage readings were taken to construct a hydrograph. Information on water levels as they were recorded on the charts were compared with those constructed from the point gage readings. Data were taken from each hydrograph at 1-minute intervals. The difference between the two readings was assumed to be error in the recorded value. These errors were averaged over each 30-minute test period. The average errors obtained by this procedure were used in the statistical analysis.

The basic experimental design was a 5 x 5 latin square with floats assigned as treatments, runs or replications assigned as rows, and recorders assigned as columns. Superimposed on this design were four 30-minute periods with different rise or fall rates. Data were subjected to an analysis of variance and means separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

Average errors for the various combination of variables are shown in Table 2. Water level measurement errors, averaged over both floats and recorders, were greater at the lower rise rate, 0.50 ft/h, and were lowest at the 1.70-ft/h fall rate. Water level errors did not differ between the 2.80-ft/h rise and 0.90-ft/h fall rates. Individual floats and recorders reacted differently during the different rise and fall rates.

There was considerable overlap in float performance at the various rise and fall rates. No individual float was better than all other floats over either the two rise rates or the two fall rates, or over the two fast or the two slow rates of stage change. Also, no individual float was better than all other floats even within a given rise or fall rate.

The 3-inch float performed as well as any of the floats at all flow rates. The 5-inch float performed as well as any of the floats at all except the 2.80-ft/h rise rate, where the 6-inch H float was better. The 6-inch L float did as well as any of the floats at the two fall rates. At the 2.80-ft/h rise rate both the 6-inch H and 10-inch floats were better with the 3-inch float best at a rise rate of 0.50-ft/h. The 6-inch H float was better than the 5-inch and 6-inch L floats at a rise rate of 2.80 ft/h, but at the other flow rates it was not as good. At the 0.90-ft/h fall rate, the 5-inch and 3-inch floats were best. At the 1.70-ft/h fall rate, the 5-inch and 6-inch L floats were best. The 10-inch float performed well except at a fall rate of 0.90 ft/h, where the 5-inch float was better.

Float weight influenced the performance of the two 6-inch floats at the fast rise and fall rates but had no effect at the two slow rates. The heavy float performed better at the fast rise rate and the light float performed best at the fast fall rate.

The recorders performed more consistently within flow rates than did floats (Table 3). At the 0.50-ft/h rise and 0.90-ft/h fall rates, there was no difference among recorders. At a rise rate of 2.80 ft/h, recorder 5 was less reliable than recorders 4, 1, and 2, and at a fall rate of 1.70 ft/h, recorder 3 was less reliable than any of the other recorders.

The mean error associated with the float-recorder systems varied among runs at three of the four flow rates. The individual effects of floats, recorders, and runs were not significant and indicate a probable float-recorder interaction at the different runs. Since the float and recorder function as a unit in each run, this information is confounded in the experiment and becomes part of the experimental error. Analysis of variance showed that differences in error among floats,

Table 2. Mean error in feet for each 30-minute period for various combinations of recorders, floats, and water level change.

Rise or fall rates ft/h	Float Diameter - inches 3	5	10	6-H	6-L
Run 1	ft	ft	ft	ft	ft
2.80 Rise	.016	.014	.012	.004	.018
0.50 Rise	.008	.011	.015	.022	.020
0.90 Fall	.008	.010	.017	.021	.017
1.70 Fall	.008	.009	.008	.016	.006
Run 2					
2.80 Rise	.013	.026	.006	.009	.014
0.50 Rise	.016	.022	.015	.017	.019
0.90 Fall	.010	.007	.017	.011	.012
1.70 Fall	.005	.004	.006	.020	.005
Run 3					
2.80 Rise	.013	.004	.014	.005	.007
0.50 Rise	.014	.014	.011	.014	.018
0.90 Fall	.009	.014	.012	.019	.012
1.70 Fall	.021	.011	.011	.013	.004
Run 4					
2.80 Rise	.007	.014	.006	.009	.015
0.50 Rise	.013	.017	.015	.020	.012
0.90 Fall	.012	.006	.014	.020	.009
1.70 Fall	.006	.007	.017	.010	.013
Run 5					
2.80 Rise	.012	.016	.008	.017	.023
0.50 Rise	.005	.010	.014	.015	.019
0.90 Fall	.012	.004	.009	.011	.010
1.70 Fall	.010	.004	.003	.006	.010

Table 3. Multiple range tests for significant differences among means of float diameter performance - 5 percent level[1].

Rise and Fall rates	Mean error
1.70 ft/h fall	.009 a
2.80 ft/h rise	.012 b
0.90 ft/h fall	.012 b
0.50 ft/h rise	.015 c

Rise and Fall Rates x Floats

2.80 ft/h rise		0.50 ft/h rise		0.90 ft/h fall		1.70 ft/h fall	
Float	Mean Error	Float	Mean Error	Float	Mean Error	Float	Mean Error
6-H	.009 a	3	.001 a	5	.008 a	5	.007 a
10	.009 ab	10	.014 ab	3	.010 ab	6-L	.008 a
3	.012 abc	5	.015 ab	6-L	.012 abc	10	.009 ab
5	.014 bc	6-L	.018 b	10	.014 bc	3	.010 ab
6-L	.015 c	6-H	.018 b	6-H	.017 c	6-H	.013 b

Rise and Fall Rates x Recorders

Re-corder	Mean Error	Re-corder	Mean Error	Re-corder	Mean Error	Re-corder	Mean Error
4	.008 a	5	.014 a	5	.009 a	4	.007 a
1	.010 a	2	.014 a	3	.011 a	1	.007 a
2	.011 a	3	.015 a	4	.013 a	5	.008 a
3	.013 ab	4	.015 a	2	.013 a	2	.008 a
5	.017 b	1	.017 a	1	.014 a	3	.015 b

Runs x Rise and Fall Rates

Run	Mean Error	Run	Mean Error	Run	Mean Error	Run	Mean Error
3	.009 a	5	.012 a	5	.009 a	5	.007 a
4	.010 ab	3	.014 ab	2	.011 ab	2	.008 a
1	.013 ab	1	.015 ab	4	.012 ab	1	.009 a
2	.013 ab	4	.015 ab	3	.013 ab	4	.010 a
5	.015 b	2	.018 b	1	.015 b	3	.012 a

[1] Comparison among means should be made only in each column within each subgroup in the table. Means followed by the same letter do not differ significantly at the 5 percent level.

runs, and recorders were not great enough to be statistically significant at the 5% level. However, differences in error among floats was great enough to be significant at the 10% level. There was a significant difference among the rise and fall rates and in the interaction of these rates with floats, recorders, and runs. These differences were significant at the 1% level for all except the interaction between rise and fall rate and run, which was significant at the 5% level. The difference in performance, or in water level errors, that are discussed are those at the 5% level, Table 3.

The proper balance of float, tape, counterweight, and recorder was not investigated in this study, but could be an important factor in water level observations. All of the components function differently on rise and fall. The float must sense the correct water level on both the rise and fall. On the rise, the counterweight must overcome the friction in the recorder and maintain tension on the tape. On the fall, the float must overcome the friction in the recorder and also lift the counterweight. A float, tape, counterweight, and recorder system that attains a good balance over the range of water level change encountered will be more accurate regardless of float size and weight.

The test facility for this experiment was constructed to minimize turbulence in the float well and the width of the hydrograph trace. In tabulating the experimental data, a cyclic shift of the hydrograph away from and then toward the true water level was noted. This action lasted several minutes and may have been due to a lack of turbulence in the float well. This indicates that elimination of turbulence in the float well may not be desirable.

SUMMARY

The 3-inch float performed as well as any size of float tested. Following, in order of preference, are the 5-inch or 10-inch, 6-inch L, and 6-inch H floats. Float performance varied considerably at the different rise and fall rates which makes extrapolation of the data to other flow rates uncertain. The limited information on float weight obtained by comparing the two 6-inch floats is inconclusive. The heavy float was best at the fast rise rate and the light float was best at the fast fall rate, with no difference at the other rates tested. Two of the recorders used in this test performed poorly at one flow rate each. Since the float, tape, counterweight and recorder operate as a system, it is often difficult to determine which component of the system is in error and needs correction. The combination of components that attains good balance over the range of water level changes encountered will yield the most reliable measurements.

LITERATURE CITED

1. Belfort Instrument Company, Instruction book for portable liquid level recorder. 1960. 1600 S. Clinton St., Baltimore, MD 21224.
2. Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11: 1-42.
3. Brakensiek, D. L., H. B. Osborn, and W. J. Rawls. 1979. Field manual for research in agricultural hydrology. Agricultural Handbook 224, United States Department of Agriculture. 547 pp.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

History and Description of 'Henderson' Red Grapefruit

Norman P. Maxwell and R. E. Rouse
Texas Agricultural Experiment Station
Texas A&M University Agricultural Research and
Extension Center, Weslaco, Texas 78596

In 1945, Sam Henderson, Sr. planted a grove of Everhard strain red grapefruit (*Citrus paradisi* Macf.) at his home place on State Highway No. 107 several miles west of Edinburg, Texas. The trees were purchased from the Everhard Nursery in Pharr, Texas.

During the freeze that occurred January 29 - February 3, 1951, the trees were frozen back to just above the bud unions. The grapefruit tops were regrown following the freeze and resulted in trees with multiple trunks. The grove was again subjected to a major freeze January 9-12, 1962, but freeze damage was not as severe as in 1951.

In 1973, an employee of Sam Henderson, Jr. noticed that the appearance of the grapefruit on one large limb was different from that on the rest of the tree. The peel had more intense red blush and yellow background color than other fruit on the tree. He cut fruit to inspect the interior and found it deeper red than the interiors of grapefruit on the other limbs of the same tree. The fruit was not harvested from this limb and was inspected late in the season. Fruit from the bud-sport limb maintained a deeper red interior color than the standard red grapefruit which had faded to almost orange by late April and May. Figure 1 shows the sport limb. Due to the large size of the limb the mutation probably resulted soon after the 1951 freeze.

Sam Henderson, Jr. contacted W. V. Ausmus, a McAllen citrus nurseryman, and asked his opinion as to whether the mutation might be worth propagating. Ausmus thought it was of value to the Valley citrus industry and started propagating the bud-sport in 1973.

Ausmus was concerned as to the virus disease status of the parent tree. Dr. Heinz Wutscher, USDA Horticulturist at Weslaco, took budwood from the parent tree to check for Psorosis (scaly bark) and exocortis. He found the tree to be free of Psorosis but Citron test plants showed the Henderson bud-sport carried exocortis virus.

Several container-grown citrus trees budded on sour orange rootstock were planted in 1975 at the Texas Agricultural Experiment Station. These trees commenced fruiting the second year after planting and comparative fruit quality data were taken the third year on 'Henderson' and 'Redblush' grapefruit. Juice samples of these two varieties showed no significant differences in maturity characteristics including ^{o}Brix, acid, ^{o}Brix to acid ratio, juice yield and ascorbic acid (Vitamin C) as reported by Cruse (1). The main difference observed was the

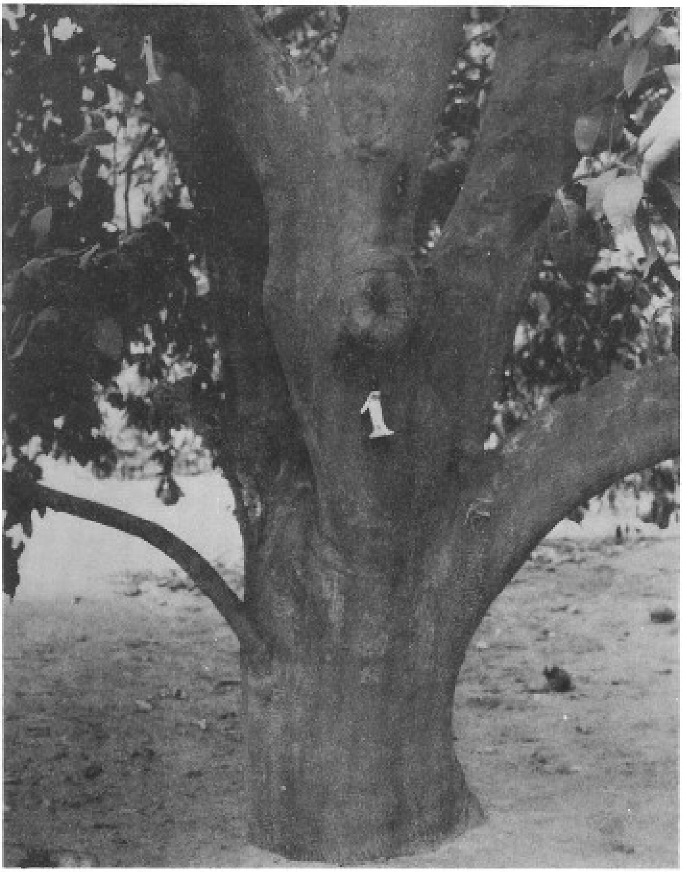

Fig. 1. Trunk and bud-sport limb of 'Henderson' red grapefruit.

interior fruit color. A Gardner color difference meter was used to measure by reflectance the amount of red and yellow color in the juice samples. Table 1 gives a summary of early and late season comparison of 'Henderson' and 'Redblush' juice color.

The 'Henderson' bud-sport is currently under test at the Texas Agricultural Experiment Station to determine what economic differences and horticultural characteristics exist in comparison to other established red grapefruit cultivars. The primary attribute of this cultivar over 'Redblush' is the increased red interior color and the fact that this color does not fade late in the shipping season.

ACKNOWLEDGEMENT

Acknowledgement is made to Mr. R. Cruse, Food Crops Utilization Research Laboratory, USDA, for use of the Gardner color difference meter and aid extended in color and Vitamin C determinations.

Table 1. Juice color comparison of 'Henderson' and 'Redblush' grapefruit.

	Juice Color	Sampling Date						
		1/12	2/15	3/1	3/15	4/3	4/17	5/1
Henderson	A[z]	10.0 a[x]	11.1 a	10.2 a	10.7 a	9.7 a	9.3 a	9.5 a
Redblush	A	4.9 b	4.5 b	4.1 b	5.0 b	4.3 b	4.0 b	3.5 b
Henderson	B[y]	11.9 a	12.9 a	13.1 a	13.5 a	13.1 a	13.1 a	13.2 a
Redblush	B	13.0 b	13.3 a	13.5 a	14.4 a	14.2 a	14.3 a	13.8 a
Henderson	A/B	0.84 a	0.86 a	0.78 a	0.80 a	0.74 a	0.71 a	0.72 a
Redblush	A/B	0.38 b	0.34 b	0.30 b	0.34 b	0.30 b	0.28 b	0.25 b

[z] Red color component.
[y] Yellow color component.
[x] Mean separation within columns and color component followed by different letter are significant at eh 5% level.

LITERATURE CITED

1. Cruse, Robert R. 1980. Maturity and processing characteristics of the 'Ray' and 'Henderson' deep pink fleshed grapefruit varieties. J. Agric. Food Chem. In Press.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Citrus Red Mite: a Potentially Damaging Pest of Texas Citrus

J. V. French, Associate Professor
Texas A&I University Citrus Center, Weslaco, TX 78596
and E. M. Hutchinson, Entomologist,
Harlingen, TX 78550

ABSTRACT

The citrus red mite, *Panonychus citri* (McG.), discovered initially in orchards near Combes, Texas in January, 1980, has now been found in the Mercedes, Adams Gardens-La Feria, Rio Hondo and Los Fresnos citrus areas. Heaviest red mite populations have been on grapefruit with > 250 mites/leaf (combined egg and motile stages) recorded in a 7-year-old Ruby Red grapefruit orchard near La Feria, Texas. Red mite were always accompanied by Texas citrus mite, *Eutetranychus banksi* (McG.), usually at lower population levels. Feeding by mixed infestations of the 2 species caused severe leaf and twig injury and extensive defoliation.

Citrus red mite, *Panonychus citri* (McG.), was found in several grapefruit and orange orchards near Combes, Texas in January 1980 (6). Feeding injury to leaves and green twigs by mixed infestations of red mite and Texas citrus mite, *Eutetranychus banksi* (McG.), resulted in extensive defoliation in some of these orchards. Since most Texas citrus growers are unfamiliar with this potentially serious pest the present communication provides information on red mite identification, life cycle, type of injury, varieties affected, and control. Additional red mite-infested-orchards have now been identified; location and magnitude of these infestations is described.

IDENTIFICATION & LIFE CYCLE

The citrus red mite, often called the 'red spider' or 'purple mite', has been an established citrus pest in Florida and California since before 1900 (2). The first infestations in Arizona were discovered in 1967 (15). While similar in size to the Texas citrus mite, the red mite is easily distinguished by its purplish-red body with numerous prominent tubercles from which arise long reddish bristles. The adult female mite is globoid in shape and about 1/50 inch in length (Fig. 1 Top). The male is smaller and has a more pointed abdomen. Adults of both sexes have 4 pairs of legs.

Red mite eggs are distinguished from eggs of other mite species by their red color and onion shape, with a vertical stalk arising from the center of each egg. Numerous fine 'guy fibrils' radiate from the top of the stalk to the surface to which the egg is attached (Fig. 1 Bottom). The majority of eggs are deposited

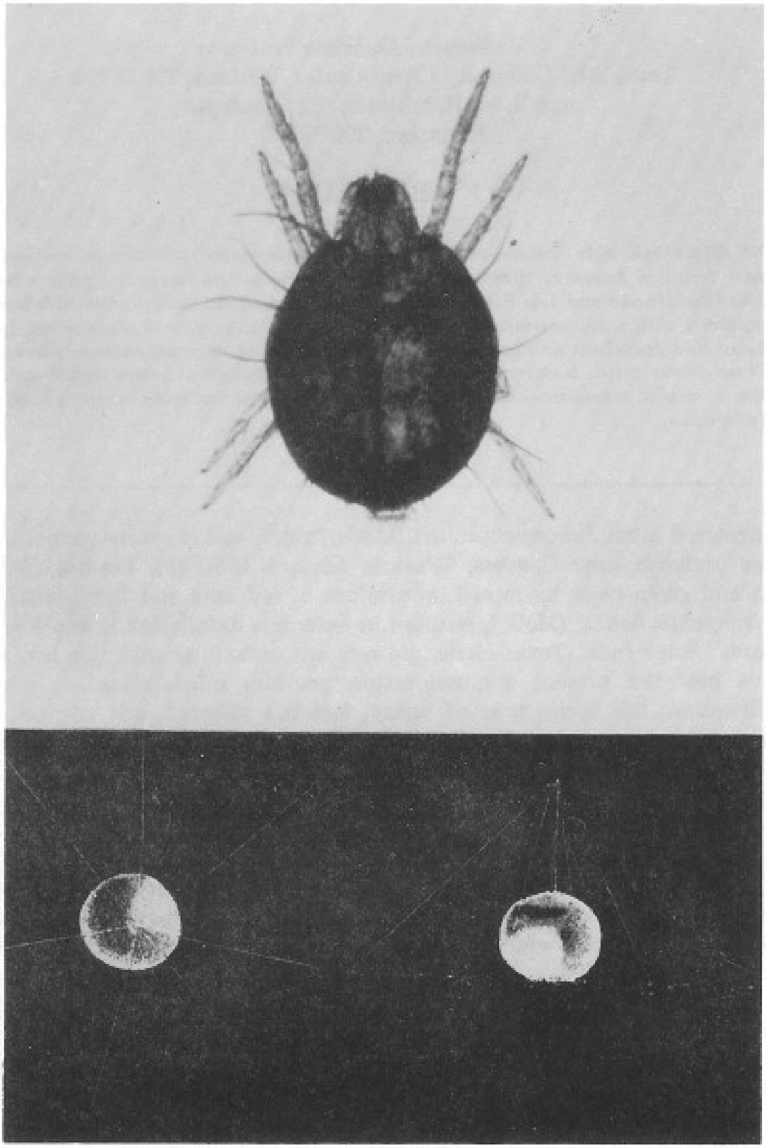

Fig. 1. Top: Citrus red mite, *Panonychus citri* (McG.) 75X. Bottom: Egg stage with central stalk & guy fibrils.

along the midrib on the top or bottom of citrus leaves. An adult female lays from 20-50 eggs, usually at the rate 2-3 per day (2). These may hatch in 2-3 days under ideal conditions or may require as long as 30 days (15). The newly hatched or larval stage mite is similar to the adult, except that it is smaller and has but 3 pair of legs. In about 3 days it molts to the nymph stage and acquires a 4th pair of legs. Within the next 6-10 days the nymph molts twice more, each time increasing in size, until the adult stage is reached. There may be several generations a year since the entire life cycle can be completed in as little time as 3 weeks.

TYPE OF INJURY

Red mites feed on leaves, green twigs and fruit. They are usually most abundant on the upper surface of young leaves. The first signs of a mite attack are minute yellow dots at the base of the leaf near the petiole. These chlorotic areas result from the extraction of chlorophyll from the tissues by the mite's piercing-sucking mouthparts. As injury increases, whole leaves and twigs appear stippled or scratched and may take on a silvered-gray cast (Fig. 2). Mite-damaged leaves often wilt and drop, leaving numerous exposed twig terminals. Defoliation is especially severe when trees under water stress are subject to drying winds. Red mites are not as prevalent on fruit as on leaves, but damage is similar to both.

In Arizona and California where lemons are grown commercially, damage to fruit can be very severe when red mites are not effectively controlled.

DISTRIBUTION AND VARIETIES AFFECTED

Citrus red mites were first found in a 9-year-old Ruby Red grapefruit orchard approximately 1/2 mile west of Combes, Texas. A survey of the surrounding area revealed 16 infested orchards, all within a 4-mile radius of the initial site. Trees in these orchards were from 6 to 25 years old and included Ruby Red and Star Ruby grapefruit and Joppa, Navel and Valencia oranges. Red mite populations varied with the variety, tree age and sampling location in the orchard (6). Highest red mite numbers were consistently recorded on young bearing grapefruit trees. Red mite infestations were always accompanied by Texas citrus mite, usually at lower population levels.

Additional red mite infestations were identified throughout the spring and early summer of 1980. Surveys were made by traversing suspect orchards in a "Z" pattern and collecting a random sample of 100 leaves. Travel direction was changed with each orchard sampled. Trees were sampled to arm's length within the canopy and in a zone from knee level to arm's length above the head. Leaves were processed through a mite brushing machine and mites were collected and counted on detergent-coated glass discs using a binocular microscope at 25X.

Several infested orchards were subsequently found outside of the Combes area, and red mites are now confirmed in the following citrus areas: Combes, Mercedes, Adams Gardens-La Feria, Rio Hondo and Los Fresnos (Fig. 3). In the Mercedes and Adams Gardens-La Feria areas, infested orchards were largely concentrated in a 3-4 mile wide corridor both north and south of Expressway 83 between Mercedes and Harlingen.

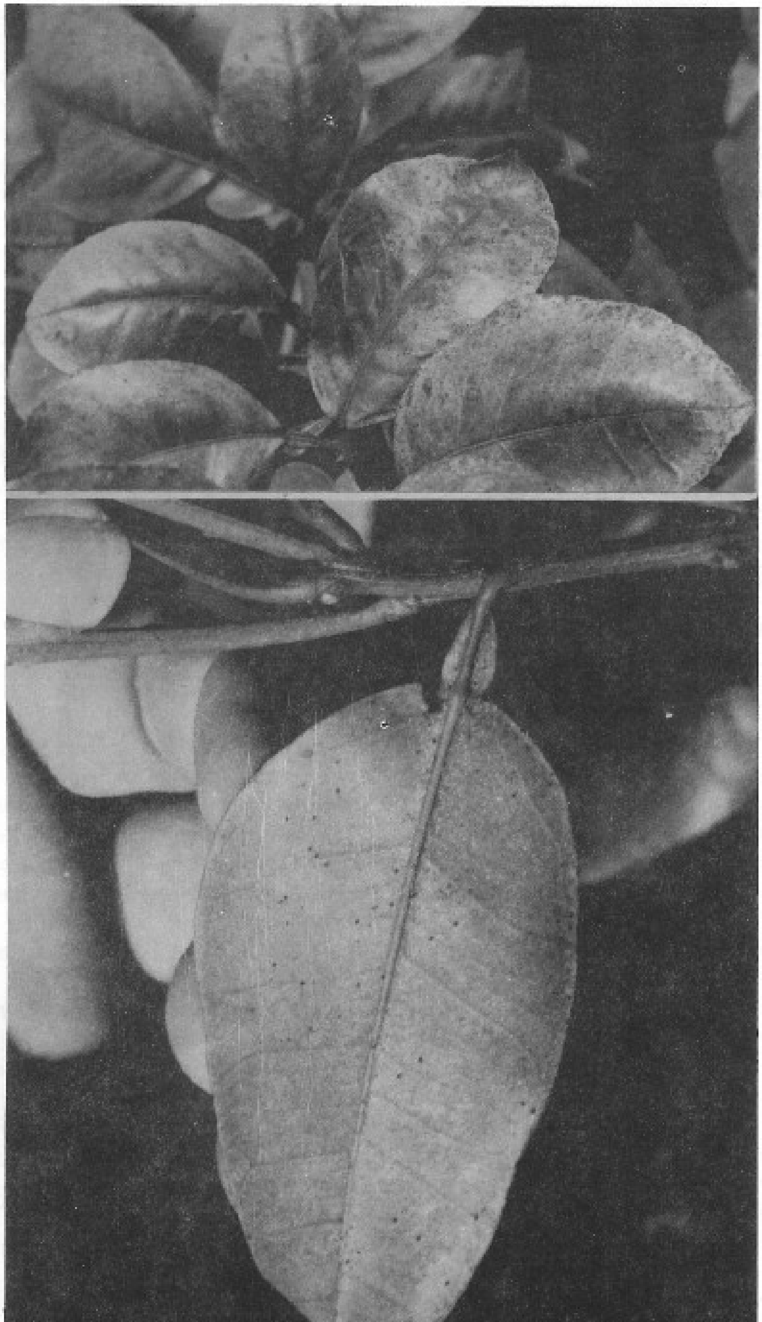

Fig. 2. Left: Citrus red mites on grapefruit leaf. Right: Severe leaf injury caused by red mite feeding.

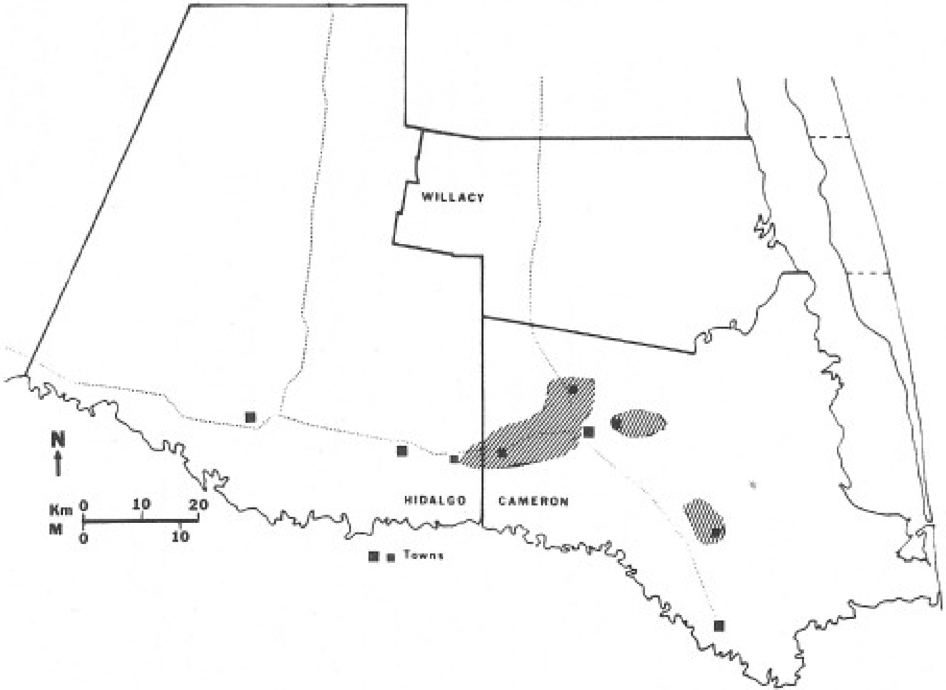

Fig. 3. Shaded areas represent locations where red mite infested orchards have been identified. Squares are major towns, from east to west: Brownsville, Los Fresnos, Rio Hondo, Harlingen, Combes, La Feria, Mercedes, Weslaco and McAllen.

In the Rio Hondo area, red mites were found in 2 orchards ca. 4 miles east and south on FM 803. In Los Fresnos, infested orchards were located northwest of the city in the Indian Lake area. All new identifications made in the spring and summer of 1980 have been on grapefruit, with the exception of a 20-year-old Orlando tangelo orchard near Combes (Table 1). The heaviest single infestation to date has been in a 7-year-old Ruby Red grapefruit orchard near La Feria with 255 mites/leaf. The extensive mite feeding injury to mature hardened foliage indicated that the infestation had gone undetected in this orchard for some time. Injury was particularly severe in the north and west sides of affected trees where extensive defoliation was observed. Although red mites were also found on the fruit, averaging 11 mites/fruit for a 100 fruit sample, no damage was apparent. Red mite infestations are being continually monitored to obtain additional information on seasonal variability of red mite populations on Valley citrus.

CITRUS RED MITE CONTROL

Information on red mite control is available from other citrus areas where it has been a major pest problem. Citrus spray oil, as well as several non-oil acaricides, have proven effective for red mite control and are labelled in California and Florida (4, 16). Several studies indicate that red mite can rapidly develop resistance to certain pesticides, particularly broad spectrum organophosphorus (OP) compounds (8, 9, 10, 11). There is also evidence that red mites can develop cross resistance to certain OP compounds and carbamate-type acaricides (10,12).

We noted that most Valley orchards with red mite infestations had not received a citrus oil spray in more than 2 years. Growers have relied heavily on spray mixes of organochlorine and OP compounds for mite and scale insect control. Several orchards received repeated OP applications during both the 1978-79 and 1979-80 seasons. Whether this heavy reliance on non-oil pesticides contributed to the red mite outbreak is not known at this time. Certain broad spectrum pesticides have previously been implicated in serious flare-ups of non-target pests (1, 5, 7). This aspect warrants considerable attention in future investigations on citrus red mite.

Ebeling (2) and Tuttle (15) list a number of insect and mite species that are natural enemies of citrus red mite. Predaceous mites of the family Phytoseiidae, particularly of the genus *Typhlodromus*, are probably the most effective. Among the insects, species of green lacewing (Chrysopidae) and brown lacewing (Hemerobiidae) and lady beetles (Coccinellidae) readily attack red mite. Impact of these and other species of the natural enemy complex known to occur in the Valley have yet to be evaluated.

A parasitic fungus, in the genus *Entomophthora*, is common on red mite in Florida (3). In California, red mites are frequently infected with a rod shaped pathogenic virus (13, 14). Both can attain epizootic levels. A survey is currently underway to determine if red mites in South Texas are affected by either of these diseases. This line of research could have an important bearing on future strategies for red mite control.

Table 1. Number of red mites found on leaves of citrus trees of various ages and types in the Lower Rio Grande Valley of Texas, 1980.

Location and Variety	Tree Age (years)	Red Mites/Leaf Egg Stage	Red Mites/Leaf Motile Stages	Red Mites/Leaf All Stages	Tx. Citrus Mites/Leaf All Stages
Combes					
Ruby Red grapefruit	10	27	34	61	2
Star Ruby grapefruit	8	28	16	45	5
Joppa orange	18	16	12	28	8
Naval orange	15	2	3	5	11
Valencia orange	18	3	1	3	27
Orlando tangelo	12	12	8	20	1
Adams Gardens-La Feria					
Ruby Red grapefruit	15	14	4	18	13
Ruby Red grapefruit	7	144	111	255	16
Los Fresnos					
Ruby Red grapefruit	17	5	2	7	2
Ruby Red grapefruit	14	45	19	64	4

ACKNOWLEDGEMENT

The authors thank Mr. Santiago Villarreal and Mr. David I. Ramos for technical assistance.

LITERATURE CITED

1. Dean, H. A. and N. P. Maxwell. 1967. Spotting of grapefruit associated with false spider mites. J. Rio Grande Valley Hort. Soc. 23:35-45.
2. Ebeling, W. 1959. Subtropical fruit pests. Univ. of Calif. Pub., Berkeley, Calif. 436 pp.
3. Fisher, F. E. 1951. An *Entomophthora* attacking citrus red mite. Fla. Ent. 34:83-88.
4. Florida Cooperative Extension Service. 1979. Florida citrus spray guide, Circular 393-E.
5. French, J. V. 1975. Control of armored scale on citrus with non-oil scalicides. J. Rio Grande Valley Hort. Soc. 29:45-51.
6. ________ and E. M. Hutchinson. 1980. Citrus red mite found in Lower Rio Grande Valley. Citrograph 65:197-198.
7. Hart, W. G., S. Ingle, M. Garza and M. Mata. 1966. The response of soft scale and its parasites to repeated insecticide pressure. J. Rio Grande Valley Hort. Soc. 20:64-68.
8. Jeppson, L. R. 1960. Resistance of mites attacking citrus. Misc. Publ. Ent. Soc. Amer. 2(1):13-16.

9. Jeppson, L. R., J. D. Complin and M. J. Jesser. 1962. Effects of application programs on citrus red mite control and development of resistance to acaricides. J. Econ. Entomol. 55:17-22.

10. __________ , __________ and __________. 1964. Comparative toxicity of some phosphoramidothioates and phosphoramidates to susceptible and acaricide-resistant strains of *Tetranychus pacificus* and *Panonychus citri*. J. Econ. Entomol. 57:878-881.

11. __________ , __________ and __________ . 1965. Response of susceptible strains of the pacific spider mite and the citrus red mite to O-Isopropyl 0-(2,4,5-Tricholophenyl) Phosphoramidate or Phosphoramidothioate. J. Econ. Entomol. 58:466-467.

12. __________, __________ and __________ . 1958. Resistance of the citrus red mite to organic phosphates in California. J. Econ. Entomol. 51:232-233.

13. Munger, F., J. E. Gilmore and W. S. Davis. 1959. A disease of citrus red mites. Citrograph 44(6):190, 216.

14. Smith, K. M., G. J. Hills, F. Munger and J. E. Gilmore. 1959. A suspected virus disease of citrus red mite, *Panonychus citri* (McG.). Nature 184:70.

15. Tuttle, D., J. May and G. Arvizo. 1973. Citrus red mite in Arizona. Coop. Ext. Sev. Bul. Q-233, 4 pp.

16. Univ. of Calif. 1980. Treatment guide for California citrus crops. Leafl. 2903.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Twig Dieback of Star Ruby Grapefruit

R. M. Davis and R. F. Leyden
Assistant Professor and Professor
Texas A&I University Citrus Center, Weslaco, Texas 78596

ABSTRACT

This is the first report of a twig dieback of Star Ruby grapefruit grown in South Texas. Twigs 1 inch in diameter and smaller on trees 7 years old and older were most commonly affected. Dying twigs were most numerous during late summer. The cause is unknown but several observations suggest dieback is related to water stress and tree size. No pathogenic organisms were implicated nor did the fungicide benomyl have any effect.

Commercial planting of Star Ruby, a deep-red-fleshed seedless grapefruit, began in 1971 in the Lower Rio Grande Valley of Texas (4). Dieback of Star Ruby twigs was first noticed in a few trees in 1977. It was not reported in 1978. During the summer of 1979 dieback was reported in Star Ruby orchards throughout the Valley. In 1980 dieback was first observed in early June and by August the condition was again widespread.

Dieback appeared suddenly in trees 7 years old and older. Younger trees were unaffected even when interplanted with older trees. Affected twigs were usually under 1 inch in diameter, although occasionally larger branches died. Twigs died quickly; leaves wilted, turned brown, and usually remained on the tree (Fig. 1 and 2). Gum exuded at the junction of dead and healthy tissue, which was often at a branch axis. Dead tissue was dry, dusky brown, and usually firm. Symptoms progressed from smaller twigs to larger ones. Up to 2 feet of growth died, sometimes unilaterally on a branch. All sides of a tree were affected but the majority of dead twigs were on the lower half of the tree. Dieback was most prevalent during late summer and ceased in the fall. The problem was found in Star Ruby grapefruit on sour orange rootstock grown under various cultural practices and occurred in orchards on several soil types: silt loam in the Brownsville area; sandy clay and sandy clay loam in the Mid-Valley; and sandy loam in the west end of the Valley.

Star Ruby originated as an induced mutation from the Hudson grapefruit (4) which in turn was a limb sport from Foster Pink grapefruit. At the Citrus Center, in addition to Star Ruby, eight other selections from the mutation study have been under observation since 1971. Several of the selections were planted in test blocks at locations throughout the Valley in 1971-72. The dieback described herein has been found in all selections derived from the Hudson and at all locations. It was also present in both old line and nucellar Hudson trees. The dieback has not been found in Foster trees.

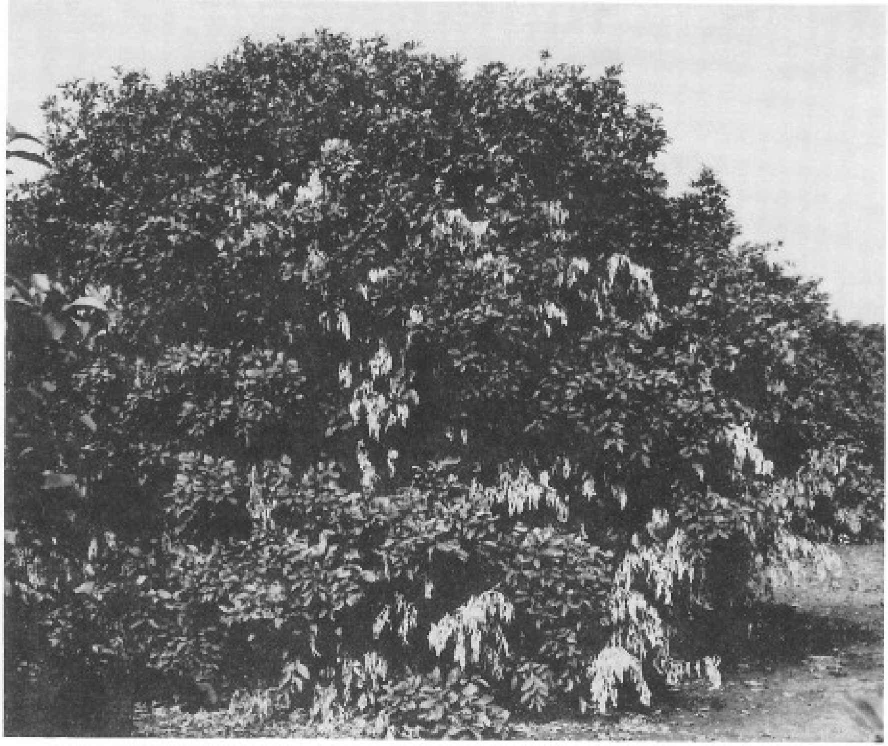

Fig. 1. Twig dieback on a 9-year-old Star Ruby grapefruit tree on sour orange rootstock.

A 2.6 acre block of Star Ruby trees planted in 1971 at the Citrus Center has received various fertilizer treatments since 1973. Dieback was present throughout the block in 1979 and again in 1980. A relationship between the rate of nitrogen fertilizer applied and the incidence of dieback appears to exist: in 1979 the percentages of trees affected were 6, 78, and 78 for the 1, 2, and 4 lb rates of nitrogen per tree; in 1980 the percentages were 27, 77, and 91.

Rates of phosphorus, zinc, and manganese are also involved in this study. No effect was found with any of these elements nor with any interactions. Leaf tissue analysis for N, P, K, Ca, Mg, Na, Mn, Zn, and Cu revealed no differences between affected and unaffected trees at any fertilizer treatment. The apparent nitrogen effect may be related to tree size.

In a block of 120 nine-year-old trees which includes old line and nucellar Hudson and several selections derived from Hudson the dieback condition was present in the summer of 1979 and to a greater extent in 1980. Observation suggested a relationship between tree size and dieback. Based on an estimate of canopy volume trees were placed in three size classes: 1 being the smallest and 3 the largest, the size expected of nine-year-old trees in this area. The incidence of dieback increased from the smaller to the larger trees (Table 1). In the earliest

Fig. 2. Close-up of dieback. Affected twigs died within a few days of the first symptoms.

Table 1. Incidence of dieback in nine-year-old Hudson and Hudson derived grapefruit trees according to tree size.

	Size class*		
	1	2	3
No. of trees	21	26	72
No. affected	9	14	54
% affected	43	54	75

*1 = smallest, 3 - largest

observations dieback was not found in trees six years-of-age and younger. A minimum tree size, age, or combination thereof appears to predispose trees to dieback.

Symptoms of Star Ruby twig dieback closely resemble those of the Robinson tangerine dieback, which is thought to be caused by the fungus *Diplodia natalensis* (3). In addition, Fawcett's description of Diplodia twig dieback (2) is almost identical to the dieback of Star Ruby. However, in some cases *Diplodia* appears to be a seconday pathogen in weakened tissue and not a primary causal agent (2).

To isolate possible pathogenic organisms from trees affected with Star Ruby dieback, chips of wood were cut from dying twigs, soaked in a 0.5% solution of sodium hypochlorite for 3 minutes, and transferred to petri dishes of vegetable juice agar. Common saprophytic or weakly parasitic fungi, including *Alternaria* sp., *Colletotrichum* sp., *Phomopsis* sp., *Fusarium* sp., and *Diplodia* sp., were frequently isolated. Twigs of nine-year-old Star Ruby trees were inoculated with pure cultures of *Colletotrichum*, *Phomopsis*, *Fusarium*, and *Diplodia* by placing a 5-mm-diameter agar plug of each fungus into a hole drilled in the wood. Controls received sterile agar. Treatments were replicated ten times. Inoculation with *Diplodia* caused a small lesion with copious gumming but the symptoms were unlike those of Star Ruby twig dieback. The other fungi failed to infect the twigs.

We also attempted to control dieback with foliar sprays of the fungicide benomyl. In June, 1980, prior to any observations of dieback, 48 Star Ruby trees in 6-tree plots scattered throughout a nine-year-old orchard were treated with benomyl at 10 oz/100 gal. The fungicide was reapplied in July. In August the orchard was surveyed; the incidence of dieback was similar in treated and untreated trees.

Other reported causes of twig dieback in citrus include an imbalance between water demands of the foliage and the ability of roots to provide adequate moisture (5) and the formation of gums in the xylem of citrus wood in periods of water stress (1). A survey of a block of Star Ruby trees under flood or drip irrigation revealed that trees under flood irrigation were more commonly affected with dieback. The irrigation practices were repeated 3 times in sets of 4 rows of 12 trees. On July 22, 1980, thirty-six trees under flood irrigation were affected while only 13 drip irrigated trees had dieback symptoms. Leaves on affected branches on these trees fell off during the winds and rain of Hurricane Allen on August 10. Thirty days later dieback symptoms had developed on 21 flood irrigated trees and two drip irrigated trees.

The relationship between water stress and tree size will be studied in 1981. We will also determine water deficits in Star Ruby trees of various sizes, compare root systems in healthy and affected trees, and study anatomical changes, including gumming, in stressed trees.

LITERATURE CITED

1. Bartholomew, E. T. 1918. Internal decline of lemons. VI. Gum formation in the lemon fruit and its twig. Amer. J. Bot. 15:548,563.
2. Fawcett, H. S. 1936. Citrus diseases and their control. Second Ed., McGraw-Hill Book Co., Inc., N. Y. 656 pp.

3. Feder, W. A., and P. C. Hutchins. 1966. Twig gumming and dieback of the 'Robinson' tangerine. Plant Dis. Reptr. 50:429-430.
4. Hensz, R. A. 1971. Star Ruby, a new deep-red-fleshed grapefruit variety with distinct tree characteristics. J. Rio Grande Valley Hort. Soc. 25:54-58.
5. Klotz, J. L., T. A. DeWolfe, L. C. Erickson, L. B. Brannaman and M. J. Garder. 1962. Twig dieback of citrus trees. Calif. Citrog. 47:74, 86-88, 90-91.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Injury Relationships in Grapefruit and Valencia Orange Trees from an Early December-Early January Freeze Sequence

John E. Fucik
Professor
Texas A&I University Citrus Center
Weslaco, TX 78596

ABSTRACT

A freeze on 9, 10 December 1978 caused mild to severe defoliation of citrus trees in the lower Rio Grande Valley of Texas. The percent defoliation on trees in three grapefruit and three Valencia orange orchards was estimated prior to a second freeze on 2, 3 January 1979. Injury to trees and fruit from the January freeze was positively correlated with leaves lost from the December freeze. Since no loss in dormancy was apparent, the January freeze injury was likely due to the loss of the radiant heat shield and heat storage capacity provided by the outer canopy leaves. Allowing for initial leaf loss differences, the grapefruit trees suffered more leaf and wood damage and less fruit injury than the Valencia oranges from the January freeze.

An early winter freeze often predisposes citrus trees to severe injury from subsequent freezes. The loss of leaves from the early freeze may reduce tree dormancy which, if followed by several days warm weather, could result in a growth flush (5). Trees in this state are very cold tender. The outer leaves and twigs protect the inner canopy tissues through the reflection, absorption and reradiation of radiant energy under and within the tree canopy (6). Mature trees contain 75% of the leaves and small twigs in the outer meter of the canopy (2). Alive, these leaves and twigs have considerable heat storage capacity (5). The winter of 1978-79 provided an opportunity to assess the relationship of leaves and twigs to freeze injury on apparently dormant and semi-cold hardened citrus trees in the field.

PROCEDURE

On the afternoon of 2 January, with a severe freeze forecast, three Valencia and three Ruby Red grapefruit orchards in the western Valley were selected as having sustained mild, medium and severe leaf loss from an earlier freeze in December. In each orchard the percent leaf loss on six randomly selected trees was evaluated. Between 13 and 18 January from 4 to 8 trees in each of these orchards were again surveyed for damage from the January freeze. The percentages of frozen leaves, twigs, and wood on each tree were estimated. Branches ca. 1.25 cm (1/2 in.) diam. or less were considered twigs, while wood was branches 1.25 to 7.5 cm (1/2 - 3 in.) diam. Frozen fruit was determined by counting the number of frozen sections at a transverse cut made a quarter way down the stem to blossom axis. Severity of freezing in the fruit was rated 1 to 5 according to the extent of injury evident at cuts made 1/2 and 3/4 the way down the same axis. Six fruits each from the top and bottom of both the north and south sides of each tree were inspected. The data from all trees were averaged for each orchard.

RESULTS

On 9, 10 December 1978 a freeze resulted in mild to severe leaf loss on citrus trees in the west end of the Valley (Table 1). Temperatures during a much harder freeze on 2, 3 January 1979 were well below 3.3 C. (26 F.) for 11 hours and caused considerable leaf, wood and fruit damage.

Table 1. Hours below selected temperatures and the minimums registered at Weslaco and Texan Gardens for two freezes in the winter of 1978-1979.

Location	Date	Hours below			Min. temp. °C
		-3.3°C (26°F)	-4.4°C (24°F)	-5.5°C (22°F)	
Weslaco	9, 10 Dec 78	2	1	0	-4.4°(24°F)
Texan Gardens	" " "	4	1	0	-4.7°(23.5°F)
Weslaco	2, 3 Jan 79	11	8	1	-5.5°(22°F)
Texan Gardens	" " "	11	8	3	-6.7°(20°F)

In Valencia orange trees freeze injury of leaves, twigs, and fruit increased as leaf loss increased (Table 2). Wood injury tended to follow the same pattern except for orchard 27/2 where site, tree condition or some other less obvious factor reduced wood losses. Grapefruit leaf loss and fruit damage from the January freeze was severe. Twig and wood damage on grapefruit, however, was more proportional to the leaf loss suffered from the December freeze (Table 3). Despite the inconsistency of Valencia wood and grapefruit leaves, the correlations between December leaf loss and January injury to leaves, twigs, and wood of both varieties together were significant. If X=% leaf loss in December and Y_1, Y_t, Y_w=% leaf, twig, and wood loss in January, respectively, the equations, correlation coefficients and standard errors of estimate for Y are:

1) $Y_1 = \frac{X}{.04 + .01X}$; .59* ; ± 18%

2) $Y_t = 43.6 + .62X$; .81** ; ± 20%

3) $Y_w = 1.7 + 7.6X$; .86** ; ± 50%

The significance levels of the correlation coefficients are * = 5%, ** = 1%.

Table 2. Damage on Valencia Orange Trees from the 2, 3 January 1979 Freeze as Related to Leaf Loss from the 9, 10 December 1978 Freeze, Texan Gardens, Lower Rio Grande Valley, Texas.

	Dec. Freeze	January Freeze				
		Tree Damage			Fruit Damage	
Orchard	Leaf Loss	Leaf	Twig[z]	Wood[y]	Frozen Sections	Severity[x]
	(%)		(% loss)		(%)	
4/1	15	70	41	5	56	3.2
27/2	36	94	53	3	99	4.6
7/8	86	100	94	62	All fruit dropped	

[z] Branches less than 1.25 cm. in diameter.
[y] Branches 1.25 - 7.5 cm. (1/2 - 3 in.) in diameter.
[x] Rating, 1 (mild) to 5 (severe), based on depth of injury from button to blossom end of fruit.

Table 3. Damage on Ruby Red grapefruit Trees from the 2,3 January 1979 Freeze as Related to Leaf Loss from the 9, 10 December 1978 Freeze, Texan Gardens, Lower Rio Grande Valley, Texas.

	Dec. Freeze	January Freeze				
		Tree Damage			Fruit Damage	
Orchard	Leaf Loss	Leaf	Twig[z]	Wood[y]	Frozen Sections	Severity[x]
	(%)		(% loss)		(%)	
18/7	15	96	68	16	85	4.0
12/8	30	98	70	26	80	4.0
21/2	58	87	85	59	62	4.1

[z] Branches less than 2.5 cm.
[y] Branches over 2.5 cm. (1 in.).
[x] Rating, 1 (mild) to 5 (severe), based on depth of injury from stem to button end of fruit.

Although there was no evidence of growth initiation on these trees, no test was made for cambial activity which might have revealed changes in dormancy associated with the December leaf loss (1). However, if cold hardiness was reduced, it had to have been proportionate to leaf loss and such a relationship has not been established. Local environmental factors, e.g. air drift or drainage, soil condition, topographic features, etc., which contributed to the variable damage from the first freeze may well have acted similarly in the second freeze. However, the differences in characteristics between the two freezes and the pattern of damage in surrounding orchards would indicate local environmental influences were quite dissimilar in the January compared to the December freeze. The correlation between the December leaf loss and January freeze injury could as well be explained on the basis of the physical condition of the trees.

Losing the outer leaves greatly reduces the canopy's ability to intercept and reflect radiant heat from underlying plant tissue and soil. Secondarily is the stored heat loss resulting from the greatly reduced heat capacity of the dead vs. living leaves and twigs. By some estimations losing 25% of the leaves could reduce the heat stored per tree by 10 to 30 kcal/°C temperature change (40-100 B.T.U./°F) (5). Since reduced cold hardiness was not a factor, the loss of the heat conserving and storing capacity of the upper canopy leaves and twigs must also have been a prime reason for the positive relationship Young and Peynado (8) found between tree damage from the 1962 Texas freeze and subsequent injury from two freezes in 1963. In mature citrus trees the greatest leaf density and 90% of the radiant energy absorption occurs in the outer meter (3 ft) of canopy (2, 4). While a 10-20% leaf loss is seldom significant, when all the loss is on the top or outside of the canopy, the effect on the energy balance within and around the tree can be quite substantial (Fig. 1).

The generally severer leaf, twig, and wood loss for grapefruit in January compared to Valencia oranges likely reflects the greater hardiness of oranges over grapefruit (3, 7). The lower leaf and twig loss in grapefruit orchard 21/2 vs. Valencia orchard 7/8 could be due to the differences in December leaf loss as well as some of the local environmental factors noted above. Fruit size and maturity could account for the slightly greater injury to the Valencia fruit compared to the grapefruit (5).

ACKNOWLEDGEMENTS

The assistance of P. James Rathwell and Robert Leyden in making the December leaf loss assessments and providing the data for Table 1 is gratefully acknowledged as is the technical assistance of Daniel Davila and Greg Panzer.

LITERATURE CITED

1. Cooper, W., S. Tayloe and N. Maxwell. 1965. Preliminary studies on cold hardiness in citrus as related to cambial activity and bud growth. Proc. Rio Grande Valley Hort. Institute 9:15.
2. Green, B. and J. Gerber. 1967. Radiant energy distribution in citrus trees. Proc. Amer. Soc. Hort. Sci. 90:77-85.
3. Hearn, C., W. Cooper, R. Register and R. Young. 1963. Influence of variety and rootstock upon freeze injury to citrus trees in the 1962 Florida freeze. Proc. Fla. State Hort. Soc. 76:75-81.

Fig. 1. These Valencia orange trees which suffered severe leaf loss from the December, 1978 freeze (top) were nearly 100% defoliated by the January, 1979 freeze (bottom).

4. Jahn, O. 1979. Penetration of photosynthetically active radiation as a measurement of canopy density of citrus trees. J. Amer. Soc. Hort. Sci. 104: 556-560.
5. Turrell, F. 1973. The science and technology of frost protection. *In.* Reuther, W. Ed., The Citrus Industry III:338-446. Univ. of Calif., Div. of Agr. Sci., Berkeley, CA. 528 pp.
6. ________ and S. Austin. 1969. Thermal conductivity and mass in stems, leaves and fruit in relation to frost resistance. *In.* Chapman, H., Ed. Proc. First Intl. Citrus Symposium II:601-608.
7. Young, R. 1963. Freeze injury to four- and nine-year old citrus cultivars and related species in the lower Rio Grande Valley of Texas. J. Rio Grande Valley Hort. Soc. 17:30-36.
8. ________ and A. Peynado. 1963. Freeze injury to citrus in the Rio Grande Valley in 1963, in relation to 1951 and 1962 freeze injury. J. Rio Grande Valley Hort. Soc. 17:43-54.

Journal Rio Grande Valley Horticultural Society, Vol. 34, 1980.

Plant Growth Regulators In Fruit Production[1]

Page W. Morgan
Department of Plant Sciences
Texas A&M University, College Station, TX 77843

Plant growth regulators are hormone-like chemicals that change the growth or yield of plants. They are not fertilizers, herbicides or insecticides, but they can improve agricultural production. As a class of chemicals they are safer to use than most other agricultural chemicals. Growth regulators are not available for all crops, but many scientists expect new uses and compounds to be developed.

Growth regulators are not new. Ethylene has been used to develop the color in oranges since the 1920's; auxins to speed up rooting of cuttings since the 1930's. Studies on rooting with auxins led to the discovery of 2,4-D. A simple organic molecule and a synthetic copy of a natural plant hormone, 2,4-D was the first highly active, selective herbicide. At low levels it is still used to prevent preharvest fruit drop.

Most of the present uses of plant growth regulators are on horticultural crops and on certain high value crops such as sugar cane and rubber. Uses of growth regulators on field crops are rare. Cotton defoliants are properly classified as growth regulators, they modify development by removing leaves, and are applied to most of the cotton acreage in the United States. Wheat in Europe is treated with a growth regulator to prevent lodging. However, most of the world's wheat, corn and rice are produced without growth regulators.

Growth regulators control many phases of plant life. A list of the effects of regulators which have commercial value include: (a) promote seed germination, (b) promote rooting, (c) promote or prevent branching, (d) cause compact growth, (e) promote flowering, (f) promote fruit set or thin fruit, (g) improve fruit size or quality, (h) remove leaves, loosen or ripen fruit for harvest, (i) prevent preharvest fruit drop, (j) increase sugar content, and (k) promote latex flow. There are several post-harvest effects: promote leaf curing, promote fruit ripening, prevent sprouting of stored tubers and bulbs.

The entire life of plants, from seed germination to the production of mature seed, is controlled by hormones. Growth regulators are synthetic hormones. Regulators often do or undo the things that hormones do but the doing is under the grower's control via the application of the chemical.

---

[1] Presented at the Thirty-second Annual Institute of the Rio Grande Valley Horticultural Society, Weslaco, Texas, 24 January 1978.

The variety of crops and the responses caused in those crops is illustrated in Table 1. There are several groups of growth regulators including: (a) auxins which promote growth and can modify bud growth and fruit shedding, (b) gibberellins which promote flowering and fruit size, (c) cytokinins which promote fruit growth and delay ageing, (d) ethylene (the commercial form is ethephon) which promotes fruit shed and fruit ripening, and (e) growth retardants some of which inhibit the production of natural gibberellins and thus cause dwarfing. These groups of compounds are joined by one other group - abscisic acid and related compounds - which inhibits growth and induces dormancy but which has not found commercial use.

The most extensive uses of growth regulators have been in the production of apples, cherries and grapes. Some applications of growth regulators are made to thin pears, peaches and apricots and to prevent preharvest fruit drop. Gibberellins are occasionally applied in citrus to prevent certain disorders. Cherries are harvested with the aid of ethephon. Ethephon is also used to aid the mechanical harvest of many other crops by loosening the fruit or concentrating maturity. Thompson seedless grapes are treated with gibberellic acid to increase berry size.

Apple production is the classic example of the application of agricultural chemicals to carefully manage a crop. Growth regulators are used to root cuttings for propagation, defoliate nursery trees for orchard planting, chemically prune and shape orchard trees, prevent unwanted shoot growth, retard shoot growth, bring young trees into flowering early, promote fruit set, thin fruit, prevent preharvest fruit drop, improve fruit quality, and regulate ripening. In no other crop have so many uses of growth regulators been perfected.

To give a true and balanced picture it is necessary to point out that even in fruit production, growth regulators are not currently useful in many crops and growing regions. Variations between chemicals, crops, varieties, and geographic regions require that much work must be done to develop something new in principle for a specific application. The cost of such work and the costs for EPA registration limit development of growth regulators for small markets. Presently it is hard to develop uses for crops of small total acreage or for uses in limited geographic areas.

There are a number of important problems in Texas that Texas Agricultural Experiment Station researchers are attempting to solve with plant growth regulators. Prevention of fruit shed in cotton and soybeans may be possible with chemical regulators. Harvesting of pecans might be improved with growth regulators as well as elimination of biennial bearing in that crop. Chemical control of blooming in peaches, plums, pears, apricots and apples, to delay blooming until after the average date of last killing frosts, would be a major benefit to fruit production in Texas. Since climate is often extreme, chemicals to increase stress tolerance in crop plants would be especially useful in Texas. Stresses would include low temperatures, salt, heat and drought. There is also interest in using growth regulators to make weeds and brush, particularly mesquite, more susceptible to kill by herbicides. Forestry is another area where research is in progress to improve plant growth with chemical regulators. In many cases breeding improved varieties of plants or discovering better cultural practices may provide a better solution than a chemical regulator. Thus, growth regulators

Table 1. Uses of Growth Regulators[1]

Use	Crops	Regulators
seed germination	lettuce, potatoes, peanuts	cytokinins, gibberelic acid (GA), ethephon
rooting	ornamentals, nursery crops	auxins
dwarfing, branching shoots	turf, trees, tobacco, apples, pears, cotton, pineapples, wheat, barley, ornamentals	maleic hydrazide growth retardants, fatty acids and alcohols, auxins
flowering	pineapple, bromeliads, cucumber, squash, lettuce, apples, pears	ethephon, GA daminozide (Alar)
fruiting	apples, pears, grapes	auxins, GA, cytokinins, daminozide
defoliation	cotton, potatoes, grapes, beans, nursery stock	specialized defoliants
sugar content	sugarcane	glyphosine
fruit harvest	many fruits, vegetables	ethephon
latex flow	rubber	ethephon
malting	barley	GA
fruit ripening, leaf curing	bananas, melons, tomatoes, citrus tobacco	ethephon, ethylene
sprout prevention	potatoes, onions	malic hydrazide

[1] Reference, Plant Growth Regulator Handbook, Plant Growth Regulator Working Group, E. F. Sullivan, Treasurer, c/o Great Western Sugar Co., Sugar Mill Road, Longmont, CO 80501.

should be viewed as another tool the agricultural producer can use to stabilize production and increase profits.

ON THE COVER

Trunks of *Phoenix canariensis*, killed by lethal decline, standing next to resistant *Washingtonia robusta* in the Brownsville area. See page 89.

JA MAR PRTG. CO., HARLINGEN, TX