# JOURNAL

OF THE

# RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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VOLUME 38, 1985

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## Aims and Objectives of the Society

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

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

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

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

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

## A Letter From The Editor

The Journal of the Rio Grande Valley Horticultural Society has for many years addressed issues of interest to those involved in producing horticultural crops not only in the Rio Grande Valley, but nationally and internationally. Reviewing the list of subscribers demonstrates the broad interest shown in the Journal, and provides justification for efforts to keep it functioning as it was intended. According to the By-laws of the Society, "the Journal shall provide a continuing record of progress in horticulture in the Rio Grande Valley", and "shall include reports of committees and articles of scientific and practical nature pertaining to horticulture". During late 1984 and early 1985, the Officers and Directors of the Society reviewed the Journal's current status and investigated ways to improve the usefulness of the publication. Recent volumes of the Journal have been composed primarily of scientific papers presenting research data, and have as a result excluded non-research papers of interest to Journal readers. Additionally, the date of publication of the Journal (January) has not promoted inclusion of papers presented at the Annual Institute.

After review and discussion, the Officers and Directors have concluded that efforts should be made to expand the scope of the Journal to include more papers from the Institute and should encourage the publication of non-research papers to complement the research papers. In order to meet these goals, the following changes in procedures have been recommended by the Editorial Committee and approved by the Society's Officers and Directors.

-Publication of the Journal will be delayed to follow the Annual Institute. This will allow inclusion of papers from the Institute and will set a deadline for submission concurrent with the Institute meeting date.

-Information previously published in national or international journals will be considered for publication in the Journal. Previously published information may be organized in a "popular" version which would highlight results without excessive data presentation, and would give Journal readers access to information which might otherwise be difficult to obtain.

-Papers not specifically presenting research data will be considered for publication. These papers may include results of Extension demonstrations, presentation of information of historical significance, reviews, or discussions of particular procedures or practices. This also will allow publication of non-technical presentations from the Institute, and would promote information of interest to a broad section of members that would not necessarily be a presentation of research data. A separate set of guidelines has been developed for preparation of "non-research" papers, and all papers submitted will be subject to review. A manuscript whose objective is the promotion of a product or service will not be accepted for publication.

Your comments and suggestions for improving the quality and usefulness of the Journal of the Rio Grande Valley Horticultural Society are solicited.

H.W. Browning
Editor

## Call for Papers

Papers are requested for inclusion in Volume 39, 1986 of the Journal of the Rio Grande Valley Horticultural Society. Manuscripts of a scientific or practical nature pertaining to horticulture will be considered for publication. All papers, including written versions of presentations from the Annual Institute, will be subject to review. Separate guidelines for the preparation of research and non-research papers are printed in the back of this issue. The deadline for submission of papers for Volume 39, 1986 will be January 31, 1986. Manuscripts for publication in the Journal may be sent to:

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

**Officers of the Rio Grande Valley Horticultural Society 1985**

*Front (left to right): Benny Bruton; Linda Boyles; Gary Kinney; Dan Fernandez; Harold Browning; and Michael Davis. Back: Bob Rouse; Julian Sauls; Gene Duos; Craig Bovee; Bob Menges; and Vic French.*

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## THIRTY-NINTH ANNUAL HORTICULTURAL INSTITUTE

**Program of Paper Presentations, January 1985**

**Fruit Section**

Citrus Canker: an Update. Dr. R.M. Davis, Pathologist, Texas A&I Citrus Center, Weslaco

The 1984 Texas Citrus Tree Inventory. Mr. Bill Arends, Texas Crop and Livestock Reporting Service, Austin

Peach Production in the Valley. Dr. Julian W. Sauls, Extension Horticulturist, TAEX TAMU, Weslaco

'Rio' Red, A new Grapefruit Release. Dr. R.L. Hensz, Director, Texas A&I Citrus Center, Weslaco

**Vegetable Section**

Effect of Bravo on Onion Yield and Screening Onions for Purple Blotch Resistance. Dr. Marvin Miller, TAEX TAMU, Weslaco

Effect of Burst on Watermelon and Cantelope Yield. Dr. Tim Hartz, Extension Vegetable Specialist, TAEX TAMU, Weslaco

Solarization for Control of Fusarium Wilt in Watermelons. Dr. Tim Hartz, Extension Vegetable Specialist, TAEX TAMU, Weslaco

Effect of Temperature on Establishment and Growth of Muskmelons. Dr. Jim Dunlap, Plant Physiologist, USDA, Weslaco

The Bee Mite Problem: A Beekeeper's View. Mr. Joe Mercer, Mercer Apiaries, Edcouch

The Bee Mite Problem: Regulatory Agency View. Mr. Dick Gaspari, Supervisory PPQ Officer, USDA APHIS, San Antonio

**Ornamentals Section**

Disease Prevention in the Nursery. Dr. Jose Amador, Extension Plant Pathologist, TAEX TAMU, Weslaco

Pesticides and Fungicides for Nursery Use. Mr. Dan Damron, Regional Representative, Mallinckrodt, Kincaid, KS

Native Plants. Dr. John Frett, Assistant Professor, Horticultural Sciences, TAMU, College Station

Foliar Diseases of Nursery Plants. Dr. Marvin Miller, plant Pathologist, TAEX TAMU, Weslaco

**Garden and Landscape Section**

Native Landscape Plants. Mr. Bob Nunn, Country Farm Nursery, Edinburg

Color in the Landscape. Mr. Gary Outenreath, Growers International, Houston

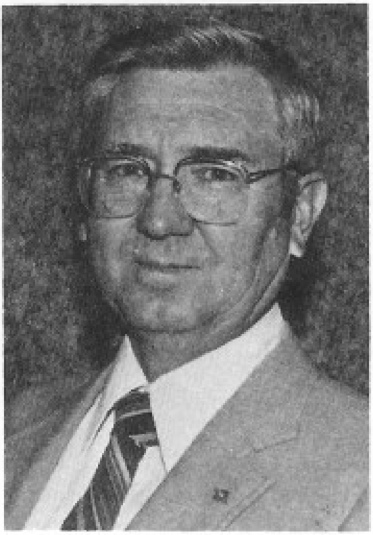
Hardy Tropical Landscapes. Mr. Bryan Hutson, Stuart Place Nursery, Harlingen

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

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

## RICHARD A. HENSZ

### 1985 Recipient of the Arthur T. Potts Award



Richard A. Hensz, Director of the Texas A&I Citrus Center and Professor of Agriculture, was born in Evansville, Indiana. After finishing high school in 1947, he came to the Lower Rio Grande Valley and farmed citrus and vegetables for several years before attending Texas A&M University where he received a B.S. degree in plant sciences. After graduation he received a commission in the Air Force and following flight training was stationed in Lybia, North Africa. After returning to Texas A&M University and completing a Masters degree in Horticulture in 1958, he joined the staff at the Texas A&I Citrus Center at Weslaco. In 1962 he took leave to finish a doctorate in the Department of Fruit Crops at the University of Florida. Following completion of his PhD in 1964, he returned to Weslaco and was appointed Director of the Texas A&I Citrus Center.

Research in citrus variety improvement led Dr. Hensz to develop the 'Star' Ruby grapefruit for which he received a patent in 1972 and to the release of 'Ray' Ruby and most recently the 'Rio' red grapefruit. His research currently involves citrus variety improvement, citrus production practices and pecan variety and production investigations in the Lower Rio Grande Valley. Dr. Hensz teaches a course in citriculture and spends considerable time with citrus growers and others in the Texas citrus industry.

Dr. Hensz is considered a world expert on citriculture. He spent 18 months in 1975-76 in Valencia, Spain, on a World Bank project helping to develop a citrus research center in that country. In 1977-78 he went on assignment to the Sudan investigating the prospects for citrus and subtropical agriculture in the Upper Blue Nile River area. In 1981 he participated in the World Citrus Congress in Tokyo, Japan, and traveled with a group of citrus breeders visiting research centers and orchards through the citrus production areas of Japan.

*Journal Rio Grande Valley Horticultural Society, Vol. 38, 1985.*

# Fruit Production of Caged 'Star Ruby' Grapefruit Trees[1]

David W. Burger, Assistant Professor
Department of Environmental Horticulture
University of California
Davis, CA 95616

Additional Index Words: *pollination, fruit yield*

## ABSTRACT

The effect of bees on fruit production of 'Star Ruby' grapefruit was studied over a two-year period. Trees that were caged and exposed to bees inside the cage produced more fruit than caged trees not exposed to bees. 'Star Ruby' trees caged during the bloom period produced fewer fruit than uncaged trees.

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Since its introduction in 1970, 'Star Ruby' grapefruit (*Citrus paradisi* Macf.) has been planted throughout the Lower Rio Grande Valley and now comprises approximately 11% of the total grapefruit acreage. As with other newly introduced cultivars, 'Star Ruby' has been the focus of several reasearch efforts to determine its response to cultivation.

Research scientists and growers alike have observed poor bearing of trees in production. Most research has centered around the apparent sensitivity of 'Star Ruby' to environmental stress (water stress, *Phytophthora parasitica* foot rot) (5,10). Nutritional studies have been performed to try to account for the low fruit production (7).

Pollination (especially cross-pollination) has been shown to be effective in increasing the production of seedless fruit in 'Star Ruby' (2,3). These studies have been conducted by using hand-pollination techniques and may not accurately reflect field conditions (1,6). A two-year field study was initiated to determine the effects of pollination by bees on the production of fruit in 'Star Ruby'.

## MATERIALS AND METHODS

Nine, 9-year-old 'Star Ruby' grapefruit trees growing in solid plantings were randomly selected in March, 1982 to be used in a caged-tree study. Cages made of wood and dark-green nylon shade cloth (25% shade) were placed around 6 of the 9

[1]Experimentation performed at the Texas A&I University Citrus Center, Weslaco.

selected trees (Figure 1). The cages formed a cube measuring 12 feet x 12 feet x 12 feet. All 9 trees required some pruning so that no part of the tree touched the nylon cage. Careful attention was given to this pruning so that all trees were pruned the same. At anthesis, small beehives (nukes) were placed in the cages of 3 trees. This procedure resulted in the implementation of three treatments with three replicates in each: 1) uncaged trees, 2) caged trees without bees, 3) caged trees with bees inside the cage. The cages were dismantled after flowering was complete and the number of fruit on the experimental trees were counted in November, 1982.

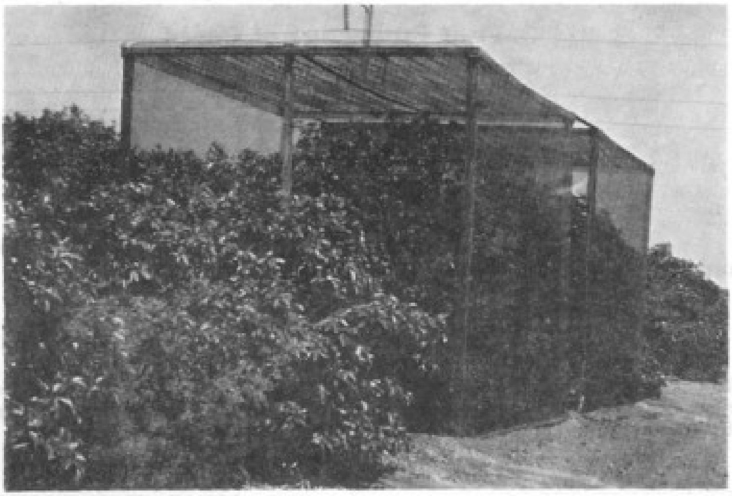

**Fig. 1.** Nylon shade-cloth (25% shade) cages surrounding 'Star Ruby' grapefruit trees just prior to anthesis.

A second, caged-tree experiment was begun in March, 1983. Twelve, 5-year-old 'Star Ruby' grapefruit trees were selected. This block had alternating rows of 'Star Ruby' and a closely related, unnamed selection originating from the same irradiated seed lot as 'Star Ruby'. The 12 trees were divided into two blocks based on their location in the row. Three pairs of adjacent trees were used in each block. In each pair, one tree was caged in a 12 foot x 12 foot x 12 foot nylon cage (25% shade cloth), the other was not caged. At anthesis, ca. 40 beehives (active supers) on wood pallets were placed near the experimental trees to insure the presence of bees on the uncaged trees. When flowering was completed, all cages were removed. In January, 1984, the total number of fruit on each of the 12 trees was counted. Fruit that had recently dropped due to the December, 1983 freeze were also counted in the total.

Data from both experiments was analyzed by the analysis of variance, and means were separated by Duncan's New Multiple Range Test.

## RESULTS AND DISCUSSION

Caged trees without bees produced no fruit, caged trees with bees produced 18 fruit/tree and uncaged trees produced 64 fruit/tree in 1982 (Table 1). Overall, the fruit production from the three control trees is low compared to other trees in the same block (mean = 162 fruit/tree). The most likely reason for this is the pruning that was performed when the cages were constructted around the trees. The effect of the cage should be insignificant if not non-existent. The cages were up only during flowering. Net photosynthesis should not have been affected since the cage material was 25% shade, allowing sufficient light penetration. If the cage did have an effect it should have been in favor of increasing fruit production since the temperature inside the cage is slightly less (1-3 °C) than outside thus decreasing temperature and water stress, and inside the cage the wind velocity is probably less reducing the chance that young developing fruit will be blown off.

**Table 1.** Effects of the presence of bees on fruit production of 'Star Ruby' grapefruit.

| Treatment | Fruit per tree |
|---|---|
| Caged tree, no bees | 0 c |
| Caged tree, with bees | 18 b |
| Uncaged tree, control | 64 a |

Means followed by a different letter are significantly different at the 0.1% level using Duncan's New Multiple Range Test.

These results indicate that open pollination is beneficial in the fruit production of 'Star Ruby'. This finding corroborates the findings from previous hand-pollination studies (2,3). Also, it is apparent that the presence of honeybees can increase 'Star Ruby' fruit production.

Similar results were obtained in the 1983 study where it was found that uncaged trees produced ca. 4 times as many fruit as caged trees (Table 2). The fruit production values for uncaged trees are well within the range of expected values (unpublished production records, Texas A&I) for fruit production of 5-year-old 'Star Ruby' trees. Fruit size, seed count, and internal quality measurements were not made because of the freeze that occurred.

The results from this study suggest that bee visitation (likely a pollinating activity) in the field can increase fruit production of 'Star Ruby' grapefruit. There are numerous accounts of the beneficial effects of controlled pollination on the production of fruit in several citrus cultivars (4,8,9). Fruit production in 'Star Ruby' can be increased by controlled hand pollinations (3). This study compliments earlier work by demonstrating similar responses to pollination in the field.

**Table 2.** Effect of bee visitation on fruit production of 'Star Ruby' grapefruit.

| Treatment | Fruit per tree |
|---|---|
| No cage, bee visitation | 94 a |
| Caged tree, no bee visitation | 22 b |

Means followed by a different letter are significantly different at the 0.1% level using Duncan's New Multiple Range Test.


## ACKNOWLEDGEMENTS

The author wishes to thank Mr. Wayland Chandler for his cooperation in handling the bees used in this study, Mr. Buddy Edwards and crew for constructing the cages, Mr. John Wiginton for technical assistance, and Dr. R. Michael Davis and Mr. Howard Wilhite for the collection of data.


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*Journal Rio Grande Valley Horticultural Society, Vol. 38, 1985.*

# Review of Citrus Rootstocks for Texas Following the 1983 Freeze

R.E. Rouse
Texas Agricultural Experiment Station
Weslaco, TX 78596

Additional Index Words: *Citrus sinensis, Citrus paradisi*, grapefruit, orange

## ABSTRACT

**Within the scope of presently evaluated rootstocks, sour orange (*Citrus aurantium* L.) continues to be the best adapted stock for the Rio Grande Valley. Where soils are suitable, the Rio Grande Valley should diversify and lessen the potential loss to tristeza virus by using Swingle citrumelo (*C. paradisi* x *Poncirus trifoliata* L. Raf.) and Carrizo or Troyer citrange (*C. sinensis* x *P. trifoliata* L. Osb.). Virus-free budwood should be used when budding to trifoliata hybrid stocks and is also suggested for use with sour orange.**

The freeze which devastated citrus in the Lower Rio Grande Valley in December 1983 was one of the worst recorded in the area. The citrus acreage is estimated to have been reduced from near 70,000 acres to approximately 30,000 acres (16). During the rebuilding period there is a rare opportunity to make major improvements in the quality and productivity of the industry. Following the 1951 and 1962 severe freezes, major changes were the elimination of psorosis as a disease problem and a shift from white to red grapefruit, respectively. Advancements in rootstocks, cultivars, irrigation, soil management, cold protection, planting density and other cultural practices since 1962 are significant and implementation should begin immediately.

Citrus trees normally consist of 2 components, a rootstock and a scion. Graftage of citrus was not established as an accepted commercial practice until the late 19th Century (64) when it was learned that grafted trees bear earlier and disease problems could be lessened by grafting onto resistant rootstocks. As a result, virtually all citrus is propagated by some means of graftage, generally by T-budding.

Sour orange has been the primary rootstock used in Texas because of its overall adaptability to alkalinity, salt, disease, cold, and heavy and often poorly drained soils. Its broad adaptability has encouraged exclusive use even though it is susceptible to tristeza virus. The primary reasons for interest in new rootstocks are the opportunity for increased yields and the failure of sour orange in many parts of the world due to citrus tristeza virus.

The 1983 freeze provides an opportunity for the Texas citrus industry to diversify rootstocks when replanting lost trees. In Texas, rootstock susceptibility or tolerance to tristeza, nematodes, cotton root rot, foot rot, compatibility with scions, soil, salt, cold and alkalinity are factors to consider. Within the scope of present evaluations, the most promising rootstocks for diversifying with sour orange are the trifoliate hybrids Swingle citrumelo, Carrizo citrange and Troyer citrange. Characteristics of these rootstocks are compared in Table 1. When using these stocks propagation with virus-free budwood is required, and should be a standard practice with all budding in an effort to upgrade the citrus industry.

**Table 1.** Characteristics and adaptability of 5 citrus rootstocks to conditions in the Lower Rio Grande Valley of Texas[z].

| Characteristic | Sour orange | Swingle citrumelo | Carrizo & Troyer citrange | Cleopatra mandarin |
|---|---|---|---|---|
| Diseases | | | | |
| Phytophthora | Resistant | Resistant | Resistant | Susceptible |
| Armillaria | Susceptible | Tolerant | Susceptible | Susceptible |
| Tristeza | Susceptible | Tolerant | Tolerant | Tolerant |
| Exocortis | Tolerant | Tolerant | Susceptible | Tolerant |
| Xyloporosis | Tolerant | Tolerant | Tolerant | Susceptible |
| Citrus Nematode | Susceptible | Resistant | Tolerant | Susceptible |
| Fruit Yield | Moderate | Excellent | Good | Moderate |
| Fruit Size | Average | Good | Good | Small |
| Fruit Quality | Good | Good | Good | Good |
| Cold Hardiness | Hardy | Hardy | Hardy | Hardy |
| Salt Tolerance | Average | Low | Low | Good |
| Alkalinity | Tolerant | Tolerant | Susceptible | Susceptible |
| Poor Soil Drainage | Tolerant | Susceptible | Susceptible | Susceptible |
| Tree Growth | Average | Good | Good | Fair |
| Tree Size | Average | Average | Average | Average |
| Special Requirements | Tristeza-free environment | Sandy soil, Exocortis-free budwood | Light soil, Exocortis-free budwood | Xyloporosis-free budwood |

[z]In some cases there may be exceptions but, in general, the characteristics hold true.

A number of different citrus rootstocks are used in the various citrus-producing areas of the world. Each has been selected as best adapted to the area in which it is used. Sour orange has always been considered to be one of the best rootstocks for sweet oranges, grapefruit and tangerines in all of the citrus growing areas. It has been especially valuable for use on heavier and relatively poorly drained soils. However, it is susceptible to the tristeza virus which is lethal to trees grafted on sour orange. This disease has necessitated the discontinued use of sour orange in most citrus growing areas of the world where it has become established.

Sweet orange and sour orange rootstocks were used about equally on the heavy but well-drained soils of California before a rapid decline of trees on sour orange stock, due to tristeza, was noted in 1939 (44). In recent years the most widely planted rootstock in California has been the trifoliate hybrid Troyer citrange.

Sour orange is practically the only rootstock used in the Lower Rio Grande Valley of Texas (11). Its overall adaptability to Valley conditions (salt, alkalinity, disease, cold, heavy and many times poorly drained soils) has encouraged its exclusive use even through it is susceptible to tristeza virus (12,13). Alternative rootstocks in Texas have particular disadvantages or have not been studied extensively. One possible substitute is Cleopatra mandarin. This rootstock is less tolerant to alkaline soils than sour orange and is a notorious low yielder during early production years. In addition, Cleopatra mandarin causes the scion to produce smaller fruit of lower quality. On the other hand, this rootstock is more cold tolerant than sour orange and is not susceptible to tristeza. Other rootstocks that hold potential for Texas are Swingle citrumelo, Troyer and Carrizo citrange (61).

The primary reason for the interest in new rootstocks for Texas is the failure of sour orange in many other parts of the world. Over 50 million trees have been destroyed by citrus tristeza virus in the past 40-50 years (24). In 1930 the then unknown disease broke out in Argentina. It subsequently swept through Brazil and Uraguay killing most trees grafted to sour orange rootstock. As in Brazil, tristeza virus wiped out citrus planted on sour orange rootstock almost overnight in Africa and California. Presently, decline-resistant Rangpur lime in Brazil are often infected with mild strains of tristeza for protection against severe, naturally-occurring strains (36). Tristeza is now endemic in most major citrus-growing areas except portions of the Mediterranean Basin, Mexico, Cuba and Texas (2). It is probable that this disease, and many others, will become more widespread and disasterous in areas where they are now minor problems. Recent ravages of tristeza in Spain and the current spread of the latent mutant form known as seedling yellows in California (45,46,47) are good examples.

Rootstocks are desirable in citrus to: improve fruit yield, fruit quality and size (8,10,21,27,30,31,35,58,59,60); adapt to different soils (39,55,57); resist virus diseases (23,37,38), fungal diseases (52,53) and nematodes (18,19,26,52,53); increase cold tolerance (14,15,61,62,63); and influence tree size (4,40).

Fruit yield is influenced by rootstock (3,6,9). Trees on rough lemon, Palestine sweet lime and Rusk and Carrizo citrange are highly productive. Trees on sour orange, Christian trifoliage orange and Troyer citrange are intermediate in productivity while those of Cleopatra mandarin, sweet orange, and other selections of trifoliate orange yield somewhat less.

Rootstocks play a major role in determining fruit quality (25,29,43,50). Highest total soluble solids are produced in fruit from trees on Rusk citrange followed by those on sour orange, sweet orange, Troyer citrange and grapefruit. Levels of soluble solids in fruit from trees on Cleopatra mandarin are intermediate while those on rough lemon, Rangpur lime and Palestine sweet lime are lowest. The fruit quality of grapefruit from trees on sour orange, Swingle citrumelo, Carrizo and Troyer citrange are similar (Table 2).

Rootstocks play a major role in determining fruit size (5), but not to the exclusion of other factors such as nutrition (51), genetic nature of the scion variety (28) and climate (42). In general, fruit are large on trees on rough lemon and Palestine sweet lime and are small on trees on Cleopatra mandarin (34). Fruit size from trees on sweet orange, sour orange, citrange stocks, and selections of trifoliate orange are intermediate.

**Table 2.** Fruit quality comparison in Texas of 'Redblush' grapefruit on sour orange rootstock and possible replacement rootstocks.[z].

| Rootstock | Total soluble solids (%) | Total acid (%) | Ratio (TSS/TA) | Juice (%) |
|---|---|---|---|---|
| Swingle citrumelo | 10.3 | 1.29 | 8.12 | 52.8 |
| Carrizo citrange | 10.3 | 1.28 | 8.12 | 51.4 |
| Troyer citrange | 10.0 | 1.27 | 7.88 | 52.8 |
| Sour orange | 10.5 | 1.28 | 8.18 | 53.2 |
| Cleopatra mandarin | 10.8 | 1.37 | 8.14 | 53.3 |

[z]Data are three-year means using 60-fruit per sample taken from 11-13 year-old trees.

It is a common belief that small or dwarfish trees produce more fruit per unit volume than larger trees (7,20,56). Also, since small trees can be spaced more closely than larger ones, it is theoretically possible that densely planted small trees could yield more fruit per acre than larger, more widely spaced ones (40,41). This idea has long been investigated in Europe where small apple trees, developed through dwarfing rootstocks and interstocks, are used extensively in commercial plantings (1,22). The influence of rootstock on tree size in citrus is well established (9,32,37), but limited efforts have been directed toward developing citrus rootstocks that produce small trees (6,33).

The presence of a clay layer has been shown to influence citrus root and tree growth (17). In a study of sweet orange on Cleopatra mandarin and rough lemon rootstocks, it was found that when the clay was close to the surface, the height of trees on Cleopatra mandarin was greater than those on rough lemon. The increased height of trees on Cleopatra mandarin was a result of root penetration into the clay and the failure of rough lemon roots to do so. However, the roots would not penetrate the clay layer when the clay content was greater than 28 to 31 percent.

In other studies in Texas using sour orange (49,54) correlation of soil texture with tree height and tree condition was found with clay at the 18 to 24 inch depth. No trees were found declining when clay content was 23% or less at the 18 to 24 inch depth. When the clay content at this depth was between 23% and 27%, trees were found in both healthy and declining conditions. This apparently represented a marginal or conditional area in which other variables and conditions may play a deciding role. Declining trees in this zone were spaced 11x22 feet and healthy trees were spaced 10x25 feet. Roots were found below the 24 inch depth only in samples from healthy trees. Clay contents of 27% and greater in the 18 to 24 inch depth resulted in declining trees. Sour orange seems to have a clay threshold of 23% which is similar to rough lemon but not as high as Cleopatra mandarin at 27%.

Yield data are represented (Table 3) from a rootstock test (48) of 'Redblush' (CES-3) grapefruit (*C. paradisi* Macf.) at Weslaco to compare the standard sour orange stock used in Texas with several potential replacement tristeza-tolerant stocks. Trees were planted in 1963 at a spacing of 15x25 feet. Yields are reported for the 5-year period 1973-77. Swingle citrumelo produced the highest yield and had the greatest percentage of commercial size fruit during the 5-year period. Cleopatra mandarin produced the greater percentage of undersize fruit.

**Table 3.** Yield comparison of 'Redblush' grapefruit on Texas standard sour orange rootstock and possible replacement rootstocks known to be tolerant to tristeza virus.

| Rootstock | Yield: Kg (lbs) tree[z] | Yield: Percentage from sour orange | Yield: Tons/acre at 116/trees/acre |
|---|---|---|---|
| Swingle citrumelo | 234 (515)a | +49.7 | 29.9 |
| Rangpur x Troyer | 205 (452)a | +31.4 | 26.2 |
| Troyer citrange | 186 (410)bc | +19.2 | 23.8 |
| Morton citrange | 175 (386)c | +12.0 | 22.4 |
| Sour orange[y] | 156 (344)c | 0 | 20.0 |
| Cleopatra mandarin | 141 (310)c | − 9.9 | 18.0 |

[z]Five-season mean for crop years 1973-77, trees 10 through 14 years old.

[y]Standard rootstock in Texas.

In Texas the susceptibility or tolerance to tristeza, nematodes, cotton root rot, and foot rot are all factors that must be considered. The tristeza-susceptible sour orange stock might be replaced by Cleopatra mandarin which is more tolerant to salt, cold and tristeza, but is slower coming into bearing, produces smaller fruit, and might be lost to cotton root rot to which sour orange is more tolerant. Within the scope of presently evaluated stocks, potential remains with the trifoliate hybrids, Swingle citrumelo, Troyer, Carrizo and Morton citrange. If any rootstock should replace the tristeza-susceptible sour orange in Texas, it probably will not be one which is outstanding in all respects. It will be one with no serious weakness and one which is average in many respects. Yet in any rootstock investigation, yield must be the primary criterion for evaluation, and any stock not consistently producing high yields should not be considered.

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# Potential for Commercial Peach Production in the Lower Rio Grande Valley

Julian W. Sauls, Extension Horticulturist
Texas Agricultural Extension Service
Weslaco, TX 78596

## ABSTRACT

Commercial peach production in the lower Rio Grande Valley appears to have good potential. Grower interest has been stimulated by the availability and performance of 3 well-adapted cultivars which produce good quality fruit during late April to early May when very few fresh peaches are available. Thus, earliness and quality should generate higher returns than peaches in other areas. However, the lack of an established research base and the climate of the Valley combine to prohibit a direct transfer of production recommendations from other peach-producing areas of Texas, consequently such knowledge is being developed by experience. Currently, there are approximately 400 acres of non-bearing orchards in the Lower Rio Grande Valley, with additional acreage anticipated.

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Peaches have been grown in home gardens in the Lower Rio Grande Valley for many years. Most such trees are seedlings and are considered to be near-native. Fruit size is normally small, quality is variable and maturity dates range from spring into summer.

Some of the early-released varieties of low-chilling, short-cycle peaches have been introduced into the Valley, but none apparently succeeded as commercial plantings. However, such varieties as 'McRed' and 'Flordabelle' are still widely grown in area gardens.

Renewed interest in commercial peach production began with the establishment of a peach variety trial at the Texas A&M University Agricultural Research and Extension Center at Weslaco in January, 1980. Production records, tree performance and fruit quality led to the recommendation of 3 varieties for commercial plantings (Table 1).

A 2-acre demonstration planting of 'EarliGrande' peach was established near Linn in Northern Hidalgo County in 1981. This orchard has not demonstrated its full potential, partly due to lack of knowledge as to the best cultrual practices for the Valley.

Unfortunately, cultural practices recommended for traditional peach-producing areas in Texas do not transfer completely to Valley conditions, so the Texas Agricultural Extension Service, the Texas Agricultural Experiment Station and commercial growers are cooperating to determine the best cultural programs to follow for this area.

**Table 1.** Characteristics of 3 Peach Cultivars for Commercial Orchards in the Lower Rio Grande Valley.

| Cultivar | Chilling Hours | Days From Bloom to Maturity | Fruit Size (in.) | Stone | External Color (% Red) | Ground Color | Potential Mature Tree Production (lbs.) |
|---|---|---|---|---|---|---|---|
| EarliGrande | 200 | 73- 77 | 2.5 | Semi-cling | 40 | Yellow | 160 |
| Flordaprince | 150 | 78- 83 | 2.2 | Semi-cling | 80 | Yellow | 130 |
| FlordaGrande | <100 | 100-105 | 2.5 | Free | 60 | Yellow | 185 |

## Current Situation

Approximately 175 acres of peaches were planted in January, 1984, primarily at Rio Grande City and Linn. Approximately 225 acres were established in January, 1985, mostly near Linn, but with some smaller plantings in the Mid-Valley area

Present indications are that additional acreages will be planted each winter for the next few years as more growers become interested in peaches and as their potential in the Valley is further demonstrated in existing orchards.

## Site Selection

Bloom generally occurs in early February and is thereby subject to potential freeze or frost damage. Consequently, peach orchard sites should be selected for good air drainage to reduce potential frost risk.

Soils should be deep and have good drainage, both surface and internal, as peach trees do not tolerate excess soil moisture. Moreover, the soil should be free of underlying caliche layers closer than 5 feet from the surface. Iron deficiency will occur in alkaline soils, so soil pH should not exceed 8.0, preferably being below 7.5.

Soils having a history of cotton root rot should be avoided, as this disease may be a major factor in the productive life of a peach orchard in the Valley.

## Irrigation

A mature peach tree will use approximately 200-275 gallons of water per week during the summer months. Any irrigation system which is designed to apply the required amount of water where and when it is needed will be satisfactory for peach production. Approximately 56% of the current acreage is under drip irrigation and 40% is under microsprayers, with the small remaining acreage being flood-irrigated. The advantages and disadvantages of the various irrigation systems can be discussed with local Extension personnel.

Orchards in established irrigation districts use water from the Rio Grande, but those in other areas have to depend upon well water. Total soluble salts in well water should be less than 1,500 ppm and boron content should be less than 1 ppm.

## Tree Spacing

The current recommendation is to plant peaches at 18x24 feet, which provides 101 trees per acre. However, in-row spacings may be 15-18 feet and between-row spacings of 22 and 25 are being used. Due to the rapid growth and large size of standard peach trees, spacings less than 15x22 cannot be recommended.

Nursery trees are budded in early summer for winter delivery. Consequently, orders must be placed by early June. The preferred tree sizes (height) for planting are 30-36 inches and 3-4 feet. Smaller trees are slightly less costly, but do not appear to establish and develop as quickly as the larger sizes.

## Production Practices

Planting, irrigation scheduling, nutrition, weed control, pest control, pruning and fruit thinning are all critical for maximum production of quality peaches. Existing research and demonstrations are expected to provide better information each year as we attempt to modify and adapt the recommendations from other areas of Texas.

The economics of peach orchard establishment and production are being determined as current plantings develop. At this point, it appears that establishment costs, excluding an irrigation system, are lower than for citrus due to the somewhat lower cost of bare-root peach trees. However, production costs are expected to be higher than for citrus, mainly due to labor costs for the necessary pruning and fruit thinning.

## Pest Management

Intensive pest management is critical for the production of quality fruit, particularly during the time fruit is present. Existing pests and management strategies for the Valley are being developed as the orchards mature and pests can be identified.

Peach rust has caused premature defoliation in some cases, usually during the summer months. Other diseases that affect the fruit and foliage have not been considered serious, although such diseases as brown rot and bacterial spot could become serious as orchards mature and more orchards are established.

Catfacing insects, particularly stinkbugs, will require careful observation. Plum curculio is not known to be present in the Valley, although it could be present or it could be unintentionally introduced. Spider mites and corn earworm (cotton bollworm) have required control measures in a few orchards to date.

## Major Concerns

Besides not having exact production recommendations and lacking an adequate base of research on peach production in the Valley, there are 2 major concerns for peach production in the Valley.

Peach trees are highly susceptible to cotton root rot, so peach orchards planted on soils known to have the disease will have a shortened productive life. Moreover, few, if any, soils in the Valley are free from cotton root rot. Consequently, this disease may become a limiting factor to extended successful peach production on many orchard sites, as no control measures currently exist and replacement trees cannot be replanted where cotton root rot killed a tree.

Harvesting, handling and marketing comprise the other major concern, as the peach crop must be picked, packed and shipped within 1 to 2 weeks. There are no existing packinghouses with facilities to handle peaches, although there has been some interest in modifying existing packing lines, should the volume of fruit justify such procedures. Moreover, most of the production will have to be marketed outside the Valley. However, the Valley crop should be completed about the time that competing areas begin to ship fruit.

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## Peach Cultivars for the Subtropical Lower Rio Grande Valley of Texas

R.E. Rouse
Texas Agricultural Experiment Station
Weslaco, TX 78596

Additional Index Words: *Prunus persica,* low-chilling

### ABSTRACT

Peaches may be commercially produced in the Lower Rio Grande Valley for the fresh market or the pick-your-own consumer. The cultivars 'EarliGrande', 'Flordaprince' and 'FlordaGrande' have the low-chilling requirement adapted to subtropical environments and high fruit quality not previously available. Growers interested in peaches should not overlook other production problems associated with soils, diseases and insects.

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Peach cultivars that can fruit with very little winter cold have been available for many years. However, their fruit has been of limited commercial value because of small size, soft flesh or other undesirable characteristics. Consequently, such cultivars were best suited for yard use by homeowners.

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

The 200 or less hours of temperatures below 7 °C which normally occur during the winter in the Lower Rio Grande Valley are too few to satisfy the 400 to 1200 hours of chilling required of most peach cultivars grown in the United States. (4). A program has been undertaken at The Texas Agricultural Experiment Station, Weslaco, to test peaches and nectarines that could be grown in the Lower Rio Grande Valley of Texas where no industry was previously possible due to lack of adapted cultivars suitable for commercial markets.

Only peach selections with low-chilling and potential for commercial use were obtained for testing. These included the then recommended 'McRed', 'Flordabelle' and material from the breeding programs at Texas A&M University and University of Florida. Some early cultivars that can be grown do not produce large-size fruit, particularly on young trees. As trees age 4 or 5 years, the fruit size situation is improved somewhat but the Weslaco program was interested in cultivars that mature 5.7 cm (2.25 inch) diameter fruit with heavy crops, ripening in April and May.

Trees were planted at 4.6x7.6 m (15x25 feet) spacing on well-drained soil of 7.2 pH. Trees were maintained on a regular program of fertilization, microsprayer irrigation and chemical weed control under the tree canopy. Although all the information collected for each cultivar evaluated in the program is not presented in this paper, bloom and ripening dates, fruit size and yield data were collected. Observations were made on vegetative growth, disease tolerance, insect pests and nutritional requirements.

While under test at Weslaco as numbered selections, 'EarliGrande' (1) and 'Flordaprince' (3) were released by Texas A&M and University of Florida, respectively. These are both commercial cultivars recommended for the Lower Rio Grande Valley, ripening in mid-April. 'FlordaGrande' was tested at Weslaco and in 1984 was jointly released by The Texas Agricultural Experiment Station and The Florida Agricultural Experiment Station. The performance (Table 1) and characteristics of comparable peach cultivars is presented (Table 2,3), and a description of adapted cultivars for the Lower Rio Grande Valley is given below.

**Table 1.** Mean performance of comparable low-chill peach cultivars at Weslaco, Texas, 1983 and 1984 seasons.

| Cultivar | Fruit yield (Wt./tree) | | Fruit yield (>6.0 cm) | Fruit size (Wt.) | | Fruit size (Diam.) | | Harvest dates |
|---|---|---|---|---|---|---|---|---|
| | kg | lbs | % | g | oz | cm | inch | |
| EarliGrande | 55 | (121) | 73 | 98 | (3.5) | 6.4 | (2.5) | 4/15-4/25 |
| Flordaprince | 50 | (111) | 51 | 90 | (3.2) | 5.6 | (2.2) | 4/18-4/28 |
| McRed | 49 | (107) | 12 | 80 | (2.8) | 5.3 | (2.1) | 4/25-5/05 |
| FlordaGrande | 71 | (158) | 93 | 105 | (3.7) | 6.4 | (2.5) | 5/10-5/20 |
| Flordabelle | 63 | (139) | 98 | 130 | (4.6) | 6.6 | (2.6) | 5/25-6/05 |

1. 'EarliGrande'. Trees are vigorous, large and upright. They show only slight susceptibility to disease except for rust [Tranzschelia discolor (F. Chl) Tranz and Litn]. Trees are moderately resistant to bacterial spot [Xanthomonas campestris pv. pruni (Smith) Young et al.]. Fruits range from 5.7 to 6.4cm (2.25 to 2.5 inches) in diameter. Fruit has yellow, fine textured, well-flavored flesh with slight red color next to the pit and little to no protrusion at the apex. The moderately firm flesh is semifree at full ripeness. Fruit surface varies in red blush from 25 to 75 percent and has medium pubescence; suture is smooth; pits average 2.75 cm in length (1.1 inches); and flowers are non-showy.

**Table 2.** Characteristics of comparable low-chill peach cultivars.

| Cultivar | Chilling units | Days from full bloom to ripe | Flower type | Flower bud set[z] | Leaf glands | Bacterial spot resistance[z] |
|---|---|---|---|---|---|---|
| EarliGrande | 200 | 73- 77 | non-showy | 6 | globose | 10 |
| Flordaprince | 150 | 78- 83 | showy | 7 | reniform | 4 |
| Desertred | 175 | 85- 90 | showy | 7 | globose | 5 |
| TropicSweet | 175 | 90-100 | showy | 10 | reniform | 6 |
| McRed | 225 | 90- 95 | showy | 7 | reniform | 8 |
| FlordaGrande | 75 | 100-105 | showy | 9 | globose | 9 |
| Flordabelle | 150 | 102-107 | showy | 8 | reniform | 7 |

[z]Rated on a 1 to 10 scale where 10 is most desirable.

2. 'Flordaprince'. Trees are vigorous and semi-upright with susceptibility to rust and moderate susceptibility to bacterial spot. Trees set a large amount of flower buds and require heavy thinning. Flowers are large, showy and medium pink. Trees are fully self-fertile. Fruit average 5 cm (2.0 inches) diameter at maturity. Harvest period begins in mid-April, about 5 days after 'EarliGrande'. Fruit are round with little or no tip, medium pubescence, semifree with little separation of the flesh at the pit when soft ripe. Flesh is melting, yellow, and firm with good quality, excellent flavor and strong peach aroma but of slightly coarse texture with some red near the peel when fruit are allowed to soften on the tree. Pits have a little tendency to split in final fruit increase. External fruit appearance is characterized by about 80 percent red blush including attractive dark red stripes over a yellow ground color.

3. 'FlordaGrande'. Trees require less than 100 chilling units and produce greater yields of large fruit than perviously available early peaches. Trees are semi-erect, produce strong vigorous growth and are tolerant to bacterial spot. Flowers are large, showy and self-fertile. Open flowers appear to be more frost tolerant than other early cultivars. Fruit are large for the maturity season, averaging greater than 4.6 cm (2.5 inches) diameter and over 113 g (4.0 ounces). Fruit ripen early to mid-May making it suitable for planting with 'EarliGrande' and 'Flordaprince' to extend the peach harvest season. Fruit have a shallow suture, medium-short pubescence and a slight tip when grown in Florida, which is absent when grown in Texas. External color is 50-70 percent red over a yellow ground color. Flesh is yellow, resistant to browning on cut surfaces, medium firm, smooth texture and high quality. Pit is free from flesh when fruit is ripe.

4. 'Desertred' is a large (2.5 inch), quality peach requiring 175 chilling units. 'Desertred' ripens in early May. Seed are semifree. Fruit appearance is 90% red over a yellow ground color. Flesh is yellow, firm and resistant to browning of the cut surface. Fruit shape is very good (round). Foliage and stems are moderately resistant to bacterial spot. This cultivar has not previously been grown at Weslaco, but is currently under test and appears to be well adapted.

**Table 3.** Mean fruit and flesh ratings of comparable low-chill peach cultivars.

| | Fruit | | | | | Flesh | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Red color (%) | Ground color | Shape[z] | Firm[z] | Stone freeness | Taste[z] | Texture[z] | Browning[z] | Color |
| EarliGrande | 40 | yellow | 7 | 6 | semifree | 7 | 7 | 8 | yellow |
| Flordaprince | 80 | yellow | 9 | 8 | semifree | 8 | 7 | 7 | yellow |
| Desertred | 90 | yellow | 9 | 8 | semifree | 8 | 7 | 5 | yellow |
| TropicSweet | 75 | yellow | 9 | 9 | free | 9 | 9 | 9 | yellow |
| McRed | 70 | yellow | 7 | 6 | semifree | 7 | 7 | 6 | yellow |
| FlordaGrande | 60 | yellow | 8 | 8 | semifree | 8 | 8 | 9 | yellow |
| Flordabelle | 60 | greenish-yellow | 10 | 8 | free | 10 | 9 | 9 | yellow |

[z]Rated on a 1 to 10 scale where 10 is most desirable.

5. 'Flordabelle'. Trees are vigorous and productive. Flowers are showy and fruit is large and round with yellow flesh and excellent quality. The pit is free. External appearance is poor having a greenish-yellow ground color. Ripening date is the last week in May to June. This cultivar is best suited for homeowners. A similar cultivar (Fla. 1E-138) without the greenish external ground color is being evaluated.

6. 'McRed'. Trees are large, productive and have a tendency to show iron chlorosis on alkaline soils in the Spring. Flowers are showy and fruit have yellow flesh with red streaks extending throughout and surrounding the pit which is semi-free when ripe. Fruit ripen late April and are medium size, striped red color, with oblong shape and a prominent tip. It is not acceptable for commercial production because of uneven fruit ripening and poor shipping quality. It can be used by homeowners.

7. Preparation is underway for the release of a new low-chilling, high quality, freestone cultivar. This will be the first truly freestone subtropical commercial peach on the market with quality equal to anything currently adapted to the environment of the Lower Rio Grande Valley. These selection, 'TropicSweet', was in the Florida breeding program in 1975, has a chilling requirement of 175 chilling units and ripens the last few days of April to early-May. Fruit average 6.4 cm diameter (2.5 inches), have yellow flesh resistant to browning on cut surfaces and external color is 75 percent red over a yellow background. Trees are heavy fruit bud setters requiring extensive thinning and have moderate tolerance to bacterial spot.

Growers may be interested in peaches as a new alternate crop. Three cultivars have been released in the past 4 years that have adaption to subtropical environmental characteristics, produce fruit of commercial size and quality, and have earliness and shipping quality not previously available. Additional peach and nectarine cultivars can be grown in the Lower Rio Grande Valley, but none currently are of commercial interest. Growers interested in peaches should not become so enthusiastic with the release of these improved selections that they overlook problems of diseases, nematodes, and insects associated with cultural management.

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# Timing of a Single Fungicide Application for Control of Greasy Spot Rind Blotch on Grapefruit

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

## ABSTRACT

Experiments to control greasy spot rind blotch caused by *Mycosphaerella citri* were conducted in three Texas grapefruit orchards in 1982 and were repeated in two of the orchards in 1983. The fungicides cupric hydroxide, benomyl, or chlorothalonil were applied on three or four dates during summer or early fall of each year. August applications of the fungicides significantly reduced disease incidence in 1983 but not in 1982. Most applications of the fungicides in September reduced rind blotch both years. October applications did not reduce disease incidence in 1983, possibly due to atypically high rainfall in July 1983 which resulted in infection earlier than normal. In general benomyl was the most effective fungicide in controlling the disease.

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Greasy spot rind blotch, caused by *Mycosphaerella citri* Whiteside, is an external rind blemish of grapefruit (*Citrus paradisi* Macf.). The disease is characterized by small necrotic spots of the fruit rind resulting from infection of a limited number of cells surrounding the stomates of the fruit. Areas of rind adjacent to infected areas do not color normally due to retention of chlorophyll. If spots are numerous fruit may appear excessively blotchy and can be downgraded.

The epidemiology and control of greasy spot on leaves of Texas grapefruit have been reported (2), but no information is available on the timing of applications of fungicides for control of greasy spot rind blotch on Texas grapefruit. The purpose of this study was to determine timing and efficacy of single applications of three fungicides for optimum control of greasy spot rind blotch.

## MATERIALS AND METHODS

Formulations, sources, and rates of fungicides tested were: cupric hydroxide (Kocide 101 53 WP), Kocide Chemical Co., 7.5 lb/acre; benomyl (Benlate 53 WP), E.I. du Pont de Nemours and Co., 2 lb/acre; and chlorothalonil (Bravo 500 F), Diamond Shamrock Chemical Co., 0.87 gal/acre.

Fungicides were applied to red grapefruit trees on sour orange (*C. aurantium* L.) rootstocks in three orchards in Weslaco, Texas with a Hardie Speed Sprayer regulated to deliver 250 gal/acre. The tree spacings in the 5-, 8-, and 9-year-old orchards were 15x28ft., 24x24ft., and 14x24ft., respectively. In each orchard treatments were arranged in a complete block design and replicated two times with one row of eight trees per plot. Fungicides were applied on three dates in 1982 and again on three or four dates in 1983. Insects and mites were controlled throughout the two year period with spring and summer applications of chlorobenzilate alone or in combination with oil or methidathion.

In February, 1983, and January, 1984, 150 fruit from each plot (300 total) were individually inspected for the percentage of the surface of the fruit with greasy spot rind blotch symptoms. In January 1984 individual tree yields were determined from the center six trees within each plot in the 5-year-old orchard. Rainfall data were obtained from a weather station located less than one mile from all of the test orchards.

Analysis of variance and mean separation were performed on data collected from treatments made on each date of fungicide application.

## RESULTS AND DISCUSSION

In 1982 the incidence of greasy spot rind blotch was not reduced in any orchard by fungicides applied in August (Table 1). Disease incidence was reduced in orchard A by all fungicides applied in September and by benomyl and cupric hydroxide applied in October. In orchard B all fungicides applied in September or October reduced rind blotch. Cupric hydroxide and benomyl (applied in September or October) significantly reduced disease incidence in orchard C.

In 1983 applications of the fungicides in August significantly reduced greasy spot rind blotch incidence on fruit in both orchards (Table 2). In orchard A benomyl applied in September also reduced the disease. In orchard B all fungicides applied in September significantly reduced the severity of rind blotch although chlorothalonil was the least effective treatment. All fungicides applied in October were ineffective. An application of cupric hydroxide in July was also ineffective. Applications of fungicides in 1983 had no effect on fruit yield (data not shown).

Rainfall records in 1982 indicate a period of heavy rainfall in late August while in 1983 heavy rainfall occurred in July (Figure1).

The period of major ascospore release and presumably infection by *M. citri* in Texas occurs in August and September, coincident with heavy rainfall (1,2). In 1982 rind blotch infection probably occurred in September following rainfall in August; therefore, an application of a fungicide during September or October was an effective treatment. The unusually heavy rainfall in July 1983 apparently initiated a major period of ascospore release earlier than normal. As a result early applications of fungicides, but not the late applications, reduced disease incidence.

Applications of fungicides are not necessary immediately prior to or after heavy rainfall since the fungus grows epiphytically before actual infection of a leaf (3). This behavior allows a relatively broad time range for application of fungicides. Since infection of fruit in Texas is delayed until late summer (1,2), optimum timing of fungicide application for control of greasy spot rind blotch is approximately September. In general fungicides applied in September in this study were the most effective treatments. Benomyl provided better control of rind blotch than either cupric hydroxide or chlorothalonil.

**Table 1.** Influence of time of fungicide application on the severity of greasy spot rind blotch on grapefruit in three orchards, 1982.

| Date of application | Surface area of fruit with symptoms (%)[z] | | |
|---|---|---|---|
| | Orchard and age | | |
| | A | B | C |
| Treatment | 5 years | 8 years | 9 years |
| 20 Aug 1982 | | | |
| Cupric hydroxide | 6.8 c | 6.2 b | 1.0 b |
| Benomyl | 8.1 c | 7.2 b | 1.1 b |
| Chlorothalonil | 6.8 c | 6.9 b | 1.7 b |
| 28 Sep 1982 | | | |
| Cupric hydroxide | 4.6 a | 3.9 a | 0.15 a |
| Benomyl | 3.6 a | 3.7 a | 0.6 a |
| Chlorothalonil | 4.4 a | 3.9 a | 1.8 b |
| 19 Oct 1982 | | | |
| Cupric hydroxide | 4.8 b | 3.2 a | 0.8 a |
| Benomyl | 3.8 a | 3.6 a | 0.5 a |
| Chlorothalonil | 6.6 c | 3.5 a | 2.5 b |
| Untreated | 7.6 c | 7.2 b | 2.0 b |

[z]Means within each date of treatment for each orchard, including the mean for the untreated trees, followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

**Table 2.** Influence of time of fungicide application on the severity of greasy spot rind blotch on grapefruit, 1983.

| Date of application / Treatment | Surface area of fruit with symptoms (%)[z] Orchard and age A 6 years | B 9 years |
|---|---|---|
| 8 July 1983 | | |
| Cupric hydroxide | 14.8 b | — |
| 17 Aug 1983 | | |
| Cupric hydroxide | 7.0 a | 2.8 a |
| Benomyl | 5.4 a | 2.1 a |
| Chlorothalonil | 5.2 a | 4.8 b |
| 28 Sep 1983 | | |
| Cupric hydroxide | 13.5 b | 2.3 a |
| Benomyl | 5.3 a | 1.8 a |
| Chlorothalonil | 15.0 b | 4.7 b |
| 24 Oct 1983 | | |
| Cupric hydroxide | 13.4 b | 8.7 c |
| Benomyl | 12.2 b | 7.7 c |
| Chlorothalonil | 15.3 b | 5.9 c |
| Untreated | 15.0 b | 6.5 c |

[z]Means within each date of treatment for each orchard, including the mean for the untreated trees, followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

## ACKNOWLEDGEMENT

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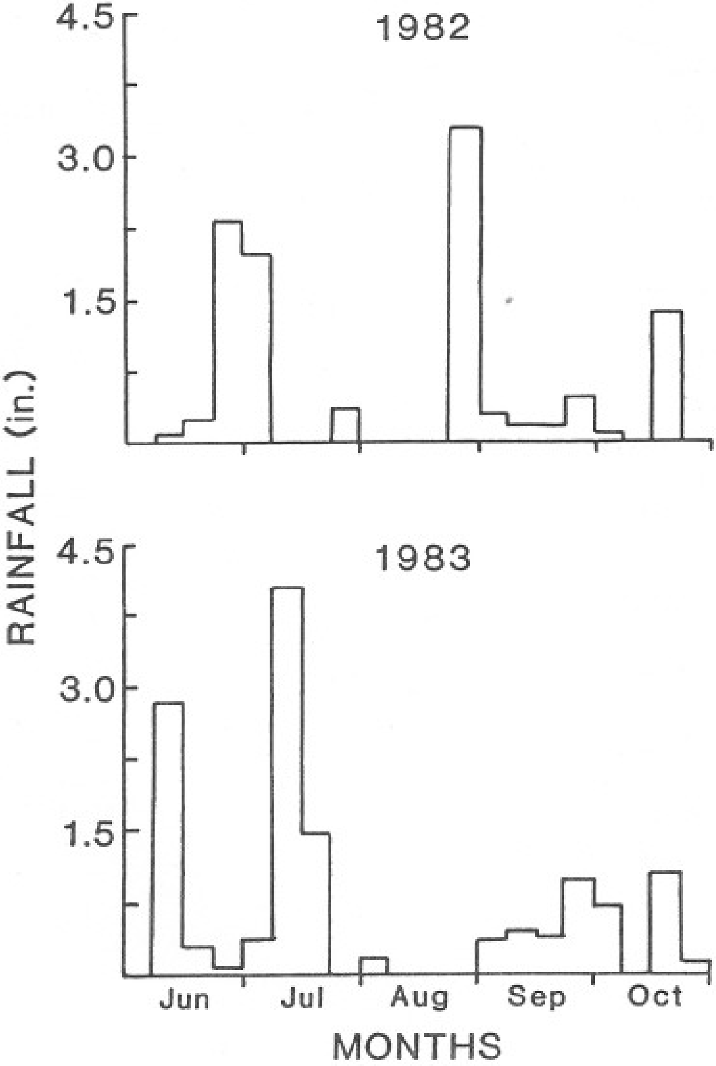


**Fig. 1.** Rainfall at Weslaco, Texas during selected months in 1982 and 1983.

# Carbosulfan and Dicofol: Efficacy on Mites as Affected by Spray Mix pH

J. Victor French and Dariusz Swietlik,
Texas A&I University Citrus Center, Weslaco, Texas 78596
and Edward Gage
FMC Corp., San Antonio, TX 78250

## ABSTRACT

Carbosulfan at 0.5 lb ai/acre and dicofol at 2.0 lb ai/acre were compared alone and in spray mixtures with Poly-Fe-Zn® foliar fertilizer at varying pH levels, for efficacy against phytophagous mites on Texas citrus. In 1983, carbosulfan + Poly-Fe-Zn spray treatments at both pH 3.5 and 7.0 provided more than 60 days suppression of citrus rust mite, *Phyllocoptruta oleivora* Ashmead. A dicofol + Poly-Fe-Zn spray treatment at pH 3.5 lost efficacy against the rust mite 2-3 weeks earlier than the same mix at pH 7.0. Spray mix pH (3.5 or 7.0) did not affect efficacy of carbosulfan or dicofol against Texas citrus mite, *Eutetranychus banksi* (McG). In 1984, carbosulfan + Poly-Fe-Zn mix at pH 4.2 provided the longest rust mite suppression (ca. 45 days), while all treatments, except dicofol + Poly-Fe-Zn mix at pH 4.2, suppressed citrus red mite, *Panonychus citri* (McG.), for 60 days.

Leaf Zn increased significantly in all treatments containing Poly-Fe-Zn; highest levels were in trees sprayed with Poly-Fe-Zn alone. There was no increase of Fe and P in the leaf tissue of sprayed trees.

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Carbosulfan (Advantage, FMC Corp. Philadelphia, PA) 2,3-dihydro 2,2-dimethyl-7-benzofuranyl [(dibutylamino) thio] methylcarbamate, an experimental acaricide-insecticide, has consistently given suppression of citrus rust mite (CRM), *Phyllocoptrata oleivora* Ashmead, in orchard trials (French and Gage, 1983). However, a potential problem with the use of carbosulfan is that it is hydrolyzed in aqueous solutions and becomes progressively less stable at lower pH, e.g., it has a half-life of 22 hrs at pH 6.0 and only 1 hr at pH 4.0. If carbosulfan is registered for use on Texas citrus, instability at low pH could be a problem because growers commonly add an acidifier to orchard spray mixes due to the alkalinity (pH 7.6-8.0) of Rio Grande River water. Spray mixtures of commercial pesticides and foliar fertilizers at recommended rates are frequently below neutral (pH 7.0) with a pH low of 3.5 not uncommon (J.V. French, unpublished data). In 1983 and 1984, orchard spray trials were conducted with carbosulfan alone and tank-mixed with a commonly-used foliar fertilizer to obtain efficacy data against two additional mite species: the Texas citrus mite (TCM), *Eutetranychus banksi* (McG.); and the citrus red mite (RdM), *Panonychus citri* (McG.); and to identify any loss of efficacy due to spray mix pH. In both trials, a registered acaricide, dicofol (Kelthane, Rohm and Haas Co., Philadelphia, PA.) 1,1 bis (chlorophenyl) 2,2,2-trichloroethanol, was included for comparison to carbosulfan. A second objective of this study was to determine any affect by carbosulfan or dicofol on uptake of Iron (Fe), Zinc (Zn) and Phosphorous (P).

## MATERIALS AND METHODS

**Chemical Formulations, Rates and pH Adjustment.** Carbosulfan was tested at the rate of 0.5 lb ai/acre throughout these trials. Dicofol was tested at the recommended rate of 2.0 lb ai/acre throughout. The foliar fertilizer, Poly-Fe-Zn® (American Agri-Services Inc., Elsa, Texas), containing 1% chelated iron, 4% chelated zinc and 7% phosphoric acid was used at varying rates to lower the pH in tank mixes with carbosulfan or dicofol. Rio Grande River water (pH $7.8 \pm 0.2$) was used for all spray mixes. To obtain a specific tank mix pH, the liquid Poly-Fe-Zn was gradually added to the carbosulfan or dicofol under agitation in 200 gal of water in the sprayer tank. A volume of 160-175 ml of Poly-Fe-Zn was needed to lower the carbosulfan or dicofol to neutral pH 7.0 and 1600-1800 ml to obtain pH 3.5. In 1984, carbosulfan and dicofol were each tank mixed with a 1420 ml (3 pt) recommended rate of Poly-Fe-Zn. Mixes were agitated for 15-30 minutes in the spray tank before application. All applications were made with an Air Blast Sprayer at 1 mph with nozzling and pressure adjusted for a spray volume of 200 gal/acre.

**1983 Efficacy Trial Against CRM and TCM.** In 1983, five spray treatments were compared for efficacy against CRM and TCM: carbosulfan + Poly-Fe-Zn at pH 7.0 and 3.5; dicofol + Poly-Fe-Zn at pH 7.0 and 3.5; and an untreated control. The test orchard consisted of 6-year-old 'Ruby Red' grapefruit trees planted in double offset rows with 15 ft X 28 ft spacing. Treatments were completely randomized and replicated twice on double row plots of 86 trees. Pre - and post-treatment counts of TCM and CRM were made at 2-3 weeks intervals. At each count, 4 leaves were randomly collected from each of 6 trees per replicate and processed through a mite brushing machine. All motile TCM were collected and counted on detergent-coated glass disks using a binocular microscope at 25X. Four fruit on each of 6 trees per replicate were examined *in situ* using a 10X hand lens fitted with a 1 $cm^2$ grid. All CRM were counted in 2 lens fields on the shaded side of each fruit.

In September, CRM feeding damage (russeting) was assessed on 6 randomly harvested fruit from each of 14 trees per replicate, i.e., 168 fruit/treatment. The percentage of fruit with moderate-severe damage (russet on one half or more of the surface area) was determined for each treatment.

**1984 Mite Efficacy and Leaf Nutrient Analysis Trial.** Six spray treatments were compared for efficacy against CRM and RdM: carbosulfan (pH 7.8); carbosulfan + Poly-Fe-Zn (pH 4.2); dicofol (pH 7.6); dicofol + Poly-Fe-Zn (pH 3.7); Poly-Fe-Zn (pH 4.2); and untreated control. Treatments were arranged in a randomized complete block design and replicated 3 times on plots of 3 trees each in a 10-year-old 'Rudy Red' grapefruit orchard on 14 ft X 24 ft tree spacing. CRM counts were made on leaves only (fruit were unavailable due to a freeze in December, 1983). CRM were counted in two-1 $cm^2$ lens fields on the lower surface of each of 12 randomly selected leaves per tree, i.e., 36 leaves per replicate. Another 24 leaves per replicate were randomly collected and processed through a mite brushing machine. Motile RdM were collected and counted as previously described for TCM.

Pre-spray and 8 weeks post-spray, a sample of 24 randomly collected ca. 4-month old leaves from each treatment replicate were processed for mineral analysis as described by Leyden (1963). Dry leaf tissue was digested in a nitric-perchloric acid mixture and analyzed for Fe and Zn using atomic absorption spectroscopy. Phosphorous was determined in the same digestion solution using the chlorostannous - reduced molybdophosphoric blue color method (Jackson, 1958).

## RESULTS

**1983 Trial.** Efficacy of carbosulfan against CRM was not affected by the addition of Poly-Fe-Zn foliar fertilizer (Table 1). Carbosulfan + Poly-Fe-Zn spray treatments at both pH 3.5 and 7.0 provided more than 60 days of mite suppression. However, the dicofol + Poly-Fe-Zn spray treatment at pH 3.5 lost efficacy against CRM 2-3 weeks earlier than dicofol + Poly-Fe-Zn spray treatment at neutral pH 7.0. Loss of efficacy and subsequent escalation of CRM populations resulted in a significantly higher percentage of russeted fruit at harvest (Table 1). The carbosulfan + Poly-Fe-Zn pH 7.0 treatment had the lowest percentage of russeted fruit, versus all other spray treatments.

Dicofol + Poly-Fe-Zn spray treatments gave better knockdown of TCM than the carbosulfan + Poly-Fe-Zn treatments (Table 2). Spray mix pH (3.5 or 7.0) did not affect the efficacy of carbosulfan or dicofol against TCM.

**1984 Trial.** All treatments gave an initial knockdown of CRM but the carbosulfan + Poly-Fe-Zn treatment (pH 4.2) provided the longest residual suppression of ca. 45 days (Table 3). Rainfall of nearly 9 inches during the latter part of the trial may have limited effectiveness of all spray treatments.

RdM populations were slow to develop in control trees. At 45 days post-spray all treatments had significantly fewer RdM than the control (Table 4), but by 60 days the dicofol + Poly-Fe-Zn no longer suppressed RdM. It is noteworthy that the Poly-Fe-Zn spray treatment alone was equally effective as other treatments against RdM.

At 8 weeks post-spray there was a significant increase of leaf Zn in trees sprayed with Poly-Fe-Zn alone or in combination with carbosulfan or dicofol (Table 5). The highest levels of leaf Zn were from trees receiving only Poly-Fe-Zn spray. There was no increase in leaf P and Fe in sprayed trees of any the treatments at 8 weeks post-spray (Table 5). No phytotoxicity was observed on trees following any of the spray treatments.

## DISCUSSION AND CONCLUSIONS

There was no reduction in carbosulfan efficacy against CRM by the addition of Poly-Fe-Zn foliar fertilizer containing an acidifier to lower the spray mix pH. The 1984 test results indicated a slight enhancement of carbosulfan residual CRM control by addition of Poly-Fe-Zn. Carbosulfan alone or combined with this foliar fertilizer provided RdM control comparable to that by dicofol; but carbosulfan was less effective in controlling TCM.

Poly-Fe-Zn used in spray mixes with dicofol apparently lessened the latter's residual effectiveness against both CRM and RdM. Since dicofol is labelled as a broad spectrum acaricide, further investigations are needed to resolve the pH incompatibility problem. Moreover, both carbosulfan and dicofol affected leaf absorption of Zn, and this aspect also warrants additional study. These acaricides could affect Zn leaf absorption through chemical and/or physical reaction with Zn rendering its passage through the leaf cuticle, cell wall and plasmalemma more difficult and/or interferes with leaf metabolic processes involved in active leaf absorption of Zn (Swietlik and Faust, 1984).

**Table 1.** Citrus rust mite (CRM) counts on fruit from 6-yr-old grapefruit trees sprayed with carbosulfan or dicofol combined with Poly-Fe-Zn foliar fertilizer, Weslaco, TX 1983.

| | | | Mean no. CRM/1 cm² of fruit surface | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | lb. ai. /acre | pH | Pre-spray | +14[z] | +30 | +45 | +60 | %[y] +80 | Russet |
| Carbosulfan + Poly-Fe-Zn 175 ml | 0.5 | 7.0 | 15.1ab[x] | 0.0b | 0.2b | 0.8c | 0.1c | 7.0bc | 2.7d |
| Carbosulfan + Poly-Fe-Zn 1800 ml | 0.5 | 3.5 | 6.5b | 0.0b | 0.2b | 0.2c | 0.3c | 3.0c | 10.0c |
| Dicofol + Poly-Fe-Zn 160 ml | 2.0 | 7.0 | 28.7a | 0.1b | 8.6b | 3.2c | 8.6bc | 19.0b | 9.9c |
| Dicofol + Poly-Fe-Zn 1600 ml | 2.0 | 3.5 | 10.8b | 1.8b | 2.7b | 15.2b | 10.9b | 32.6a | 29.2b |
| Control | — | — | 10.1b | 5.4a | 35.0a | 41.4a | 20.3a | 21.4ab | 38.0a |

[z]Days post-spray.

[y]% of the fruit at harvest with moderate-severe damage caused by CRM.

[x]Means in columns followed by the same letter are not significantly different ($P = 0.05$) by Duncan's Multiple Range Test.

**Table 2.** Texas citrus mite (TCM) counts on leaves from 6-yr-old grapefruit trees sprayed with carbosulfan or dicofol combined with Poly-Fe-Zn foliar fertilizer, Weslaco, TX 1983.

| Treatment | lb. ai. /acre | pH | Mean no. TCM/leaf | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-spray | +14[z] | +30 | +45 | +60 | +80 |
| Carbosulfan + Poly-Fe-Zn 175 ml | 0.5 | 7.0 | 4.5b[y] | 1.4b | 6.8b | 3.8b | 1.4b | 0.4b |
| Carbosulfan + Poly-Fe-Zn 1800 ml | 0.5 | 3.5 | 1.5c | 1.5b | 4.1c | 6.4a | 2.1b | 0.3b |
| Dicofol + Poly-Fe-Zn 160 ml | 2.0 | 7.0 | 17.0a | 0.5c | 1.5d | 1.7c | 5.2a | 4.0a |
| Dicofol + Poly-Fe-Zn 1500 ml | 2.0 | 3.5 | 3.7b | 0.2c | 1.5d | 3.3b | 1.7b | 0.4b |
| Control | — | 7.8 | 4.5b | 5.5a | 8.7a | 4.2b | 1.5b | 0.7b |

[z]Days post-spray.

[y]Means in columns followed by the same letter are not significantly different (P = 0.05) by Duncan's Multiple Range Test.

**Table 3.** Citrus rust mite (CRM) counts on leaves of 10-yr-old grapefruit trees sprayed with carbosulfan or dicofol alone or combined with Poly-Fe-Zn fertilizer, Weslaco, TX 1984.

| Treatment | lb. ai. /acre | pH | Mean no. CRM/1 $cm^2$ of leaf surface | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-Spray | +14[z] | +30 | +45 | +60 | Post Spray Avg |
| Carbosulfan | 0.5 | 7.8 | 8.0b[y] | 0.3b | 4.2bc | 18.6a | 13.8a | 9.2a |
| Carbosulfan + Poly-Fe-Zn 1420 ml | 0.5 | 4.2 | 11.7a | 0.2b | 1.9c | 9.6b | 13.4a | 6.3b |
| Dicofol | 2.0 | 7.8 | 13.5a | 1.9b | 3.4c | 15.3a | 20.4a | 10.3a |
| Dicofol + Poly-Fe-Zn 1420 ml | 2.0 | 3.7 | 11.8a | 0.7b | 3.1c | 22.4a | 21.7a | 12.0a |
| Poly-Fe-Zn 1420 ml | — | 4.2 | 9.5a | 0.9b | 15.9a | 10.4b | 23.2a | 12.6a |
| Control | — | 7.8 | 10.5a | 5.7a | 9.9b | 16.1a | 18.1a | 12.4a |

[z] Days post-spray.

[y] Means in columns followed by the same letter are not significantly different (P = 0.05) by Duncan's Multiple Range Test.

**Table 4.** Citrus red mite (RdM) counts on leaves of 10-yr-old grapefruit trees sprayed with carbosulfan or dicofol alone or combined with Poly-Fe-Zn fertilizer, Weslaco, TX 1984.

| | | | Mean no. RdM/Leaf | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | lb. ai. /acre | pH | Pre-Spray | +14[z] | +30 | +45 | +60 | Post Spray Avg |
| Carbosulfan | 0.5 | 7.8 | 0.1a | 0.1b[y] | 1.2a | 1.1b | 2.7b | 1.3bc |
| Carbosulfan + Poly-Fe-Zn 1420 ml | 0.5 | 4.2 | 0.1a | 0.1b | 0.2a | 0.1b | 0.6b | 0.3c |
| Dicofol | 2.0 | 7.8 | 0.1a | 0.4b | 0.6a | 2.8b | 3.1b | 1.7abc |
| Dicofol + Poly-Fe-Zn 1420 ml | 2.0 | 3.7 | 0.1a | 0.1b | 0.1a | 1.5b | 9.5a | 2.8a |
| Poly-Fe-Zn 1420 ml | — | 4.2 | 0.1a | 0.9a | 1.1a | 0.2b | 0.9b | 0.7c |
| Control | — | 7.8 | 0.1a | 0.1b | 0.6a | 5.6a | 2.8b | 2.3ab |

[z]Days post-spray.

[y]Means in columns followed by the same letter are not significantly different (P = 0.05) by Duncan's Multiple Range Test.

**Table 5.** Phosphorous, zinc and iron analysis from mature leaves of grapefruit trees sprayed 8 weeks earlier with carbosulfan or dicofol alone or combined with Poly-Fe-Zn foliar fertilizer, Weslaco, TX 1984.

| Treatment | lb ai/acre | P % dry wt | Zn ppm dry wt | Fe ppm dry wt |
|---|---|---|---|---|
| Carbosulfan | 0.5 | 0.14a[z] | 14.6c | 70.7a |
| Carbosulfan + Poly-Fe-Zn 1420 ml | 0.5 | 0.13a | 18.7b | 70.7a |
| Dicofol | 2.0 | 0.13a | 14.0c | 70.0a |
| Dicofol + Poly-Fe-Zn 1420 ml | 2.0 | 0.13a | 18.7b | 75.3a |
| Poly-Fe-Zn 1420 ml | — | 0.13a | 22.0a | 74.7a |
| Control | — | 0.13a | 14.0c | 73.7a |

[z]Means in columns followed by the same letter are not significantly different ($P = 0.05$) by Duncan's Multiple Range Test.

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# Nutritional Status and Growth Responses of Freeze-injured Citrus Trees to Mineral Foliar Sprays in the First Year of Recovery

Dariusz Swietlik, Assistant Professor
and Joe V. LaDuke, Technician
Texas A&I University, Citrus Center
P.O. Box 1150, Weslaco, Texas 78596

Additional Index Words: grapefruit, orange, nitrogen, iron, zinc, manganese.

## ABSTRACT

The December 1983 freeze caused complete defoliation, extensive wood damage, and in some cases death of whole trees in grapefruit and orange orchards of the lower Rio Grande Valley of Texas. Injured trees were pruned back to crotches between the trunk and main limbs. Analysis of leaf samples collected from flushes of growth following the freeze indicated that the freeze did not have a deliterious effect on N, P, K, Mg, and Ca nutrition in the first year of the trees' recovery. No relationship was found between severity of freeze damage and deficient or low levels of Fe, Zn, and Cu encountered in various numbers of leaf samples. However, low Mn was associated with orchards characterized by extensive freeze damage. Small growth increases were obtained from combined Fe, Zn, and Mn foliar sprays applied to recovering Ruby Red grapefruit trees with low levels of these elements.

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A period of subfreezing temperatures in December 1983 inflicted considerable damage to the citrus industry in the Rio Grande Valley of Texas. It resulted in complete defoliation and the death of most parts of scaffold limbs and even entire trees. Many growers have attempted to save injured trees by pruning them back to the crotches between main scaffold limbs and trunks. These orchards produced the first flush of growth in March the year following the freeze. However, it will take several seasons before full sized canopies will be restored. Another concern is that most trees have extensive areas of damaged bark on trunks and limbs which will not be restored and may, therefore, impede the normal flow of carbohydrates to the roots. The time lapse before sufficient amounts of carbohydrates will be manufactured by new canopies and possible disturbances of their downward translocation may bring about deficiences of sugars in the root system. This is known to have a deliterious effect on root growth and function including uptake of mineral nutrients (3).

The present study assesses the mineral nutrient status of recovering citrus trees in the first year after the freeze. In addition, growth responses of freeze-injured grapefruit trees to foliar sprays with N, Fe, Zn, and Mn were evaluated.

## MATERIALS AND METHODS

**Tree Nutritional Status.** The nutritional status of citrus trees was assessed in 20 locations throughout Hidalgo County. Half of the locations were planted to 'Ruby Red' grapefruit; the other half to 'Valencia' and 'Marrs' orange. All trees were on sour orange rootstock.

All orchards were fertilized annually with N at rates of 130-180 lb/acre in the years preceding the freeze. Phosphorous was used in two grapefruit and four orange orchards at 38 lbs. $P_2O_5$/acre. Before the freeze four grapefruit and five orange orchards were sprayed annually with Foltron (Tex-Ag Co., Mission, Texas) containing N, P, K, Mg, Fe, Zn, Mn, and Cu. Fertilizer programs were discontinued in all orchards following the freeze.

Four leaf samples were collected for mineral analysis in each orchard in August and October 1984. Six leaf samples were collected in two Weslaco grapefruit orchards (Texas A&I Citrus Center). The sampled trees were uniformly distributed over a given block. An individual sample consisted of 40 leaves and each leaf was collected from a different tree. Both the August and October samples consisted of 4-month-old leaves which developed in March and June, respectively.

Washing, drying, and grinding of leaf samples was handled as described by Leyden (12). Leaf tissue was digested in a nitric-prechloric acid mixture and analyzed for K, Mg, Ca, Na, Fe, Zn, Mn, and Cu on an atomic absorption spectrophotometer; P was determined in the same digestion solution using the chlorostannous-reduced molybdophosphoric blue color method (5). Nitrogen was determined by the Kjeldahl method following sulfuric acid digestion.

The degree of freeze damage was assessed using an index of 1-5 with 1 being the least and 5 the most extensive damage. Percent of dead and dying trees, as well as the extent of trunk bark damage on live trees, were the basis for assigning an index value to a given orchard.

Nutrient status of the orchards has been classified based on citrus leaf standards developed by Embleton et al. (2), with the modifications of N ranges for grapefruit, and P and K for both grapefruit and oranges as suggested by R. Leyden for Texas citrus (Texas A&I University, Citrus Center-unpublished).

**Foliar Spray Experiment.** The experiment was conducted in the year following the 1983 freeze in an 18-year old block of 'Ruby Red' grapefruit on sour orange rootstock. The soil was Hidalgo sandy clay loam.

The experiment was designed as a completely randomized block with 6 replications (trees) per treatment. There were four treatments: 1) untreated, control; 2) three monthly urea sprays beginning at the end of July; 3) three monthly Fe + Zn + Mn sprays on the above dates. Urea was applied at a concentration of 0.9%, Mn and Zn as 0.06% solutions of manganese and zinc sulfate, and iron as 0.06% solution of Sequestrene 330 (Ciba-Geigy Co., Greensboro, N.C. 27409). To each spray solution a non-ionic spreadersticker (Plyac - Allied Chemical Co., Morristown, N.J.) was added at 0.03% v/v. Trees were sprayed to runoff using a handgun at 100 psi.

The width of each tree canopy along and perpendicular to the rows as well as canopy height were measured in July and December 1984. This permitted the calculation of increase in these parameters during the course of the experiment.

Leaf samples for mineral analysis were taken from each tree before initiation of treatments and again in October.

## RESULTS AND DISCUSSION

**Tree Nutritional Status.** N concentrations in grapefruit and orange leaves in August and October samples fell into optiomal, high, or excessive ranges (Table 1). The other macroelements, P, K, Mg, Ca, and Na, were optimal in both grapefruit and orange samples with the exception of two August grapefruit samples and two October orange samples which indicated high K concentrations (Table 1). Also, one grapefruit orchard had high leaf Na in August and October samples (Table 1).

Optimal levels of P, Mg, and Ca found here are in agreement with earlier data for citrus in this region (4,11,12). In some orchards, low K values have been reported (4,12) but long term data (R.F. Leyden, Texas A&I University Citrus Center - unpublished) indicate that leaf K values of 1.5-2.0% are not uncommon in Valley citrus orchards. This is in agreement with our findings.

The high proportion of orchards showing high or excessive N values can be explained by: (1) high N reserves in trees due to regular, annual N fertilization at 130-180 lb/acre in years preceding the 1983 freeze, and (2) the absence of fruit in the 1984 season which otherwise would compete with vegetative growth for nitrogen (10,15).

No clear decrease trend from August to October was found with any of the macroelements (Table 1). This indicates their continued supply to the leaves through summer and autumn months. As the growing season progresses, the supply of minerals to leaves is increasingly dependent on root absorption and less on utilization of tree reserves (9). Thus, optimal or high levels of macroelements in October samples suggest that an equilibrium was maintained during summer and autumn months between the rate of top growth and uptake of macroelements by the roots.

Concentration of P in leaves in each orchard was higher in October than in August. Averages were of 0.14% vs. 0.11% for October and August samples, respectively. This phenomenon is probably related to slower vegetative growth in the second half of the growing season enabling leaves to accumulate extra P from continued root absorption (15,16). This type of relationship was also reported for N (12) but was not found in this study.

Iron was at an optimal level in all orange and most grapefruit orchards (Table 2). All August and October orange leaf samples showed deficient concentrations of Zn (Table 2); grapefruit samples were about equally distributed among low and deficient ranges of this element (Table 2).

Sixty percent of grapefruit orchards were optimally supplied with Mn, while the remainder showed low levels of this element at both leaf sampling dates (Table 2). In August, half of the orange orchards indicated optimal and the other half low Mn level. This element subsequently showed a recovery in all of the orchards previously low in Mn except one (Table 2).

In August and October all grapefruit orchards and in August all orange orchards had optimal leaf Cu level (Table 2). However, four orange orchards developed low levels of this element by October.

**Table 1.** Number of citrus orchards, out of a total of 10 grapefruit and 10 orange orchards sampled, classified by ranges of concentrations of leaf macronutrients in Hidalgo County, Texas in the year following the December 1983 freeze. (Leaves were collected from the same orchards in August and October.)

| Element | | Number of orchards | | | |
|---|---|---|---|---|---|
| Leaf concentration range | | Grapefruit | | Orange | |
| (% dry weight)[z] | | August | October | August | October |
| Nitrogen | | | | | |
| Excessive | >2.8 grapefruit<br>>2.8 orange | 2 | 0 | 5 | 6 |
| High | 2.7-2.8 grapefruit<br>2.7-2.8 orange | 3 | 4 | 3 | 3 |
| Optimal | 2.2-2.6 grapefruit<br>2.4-2.6 orange | 5 | 6 | 2 | 1 |
| Low | 2.0-2.1 grapefruit<br>2.2-2.3 orange | 0 | 0 | 0 | 0 |
| Deficient | <2.0 grapefruit<br><2.2 orange | 0 | 0 | 0 | 0 |
| Phosphorous | | | | | |
| Excessive | >0.30 | 0 | 0 | 0 | 0 |
| High | 0.21-0.30 | 0 | 0 | 0 | 0 |
| Optimal | 0.10-0.20 | 10 | 10 | 10 | 10 |
| Low | 0.07-0.09 | 0 | 0 | 0 | 0 |
| Deficient | <0.07 | 0 | 0 | 0 | 0 |
| Potassium | | | | | |
| Excessive | >2.3 | 0 | 0 | 0 | 0 |
| High | 2.1-2.3 | 2 | 0 | 0 | 2 |
| Optimal | 1.0-2.0 | 8 | 10 | 10 | 8 |
| Low | 0.5-0.9 | 0 | 0 | 0 | 0 |
| Deficient | <0.5 | 0 | 0 | 0 | 0 |
| Magnesium | | | | | |
| Excessive | >1.20 | 0 | 0 | 0 | 0 |
| High | 0.70-1.10 | 0 | 0 | 0 | 0 |
| Optimal | 0.26-0.69 | 10 | 10 | 10 | 10 |
| Low | 0.16-0.25 | 0 | 0 | 0 | 0 |
| Deficient | <0.16 | 0 | 0 | 0 | 0 |
| Calcium | | | | | |
| Excessive | >7.0 | 0 | 0 | 0 | 0 |
| High | 5.6-6.9 | 1 | 2 | 0 | 0 |
| Optimal | 3.0-5.5 | 9 | 8 | 10 | 10 |
| Low | 1.6-2.9 | 0 | 0 | 0 | 0 |
| Deficient | <1.6 | 0 | 0 | 0 | 0 |
| Sodium[y] | | | | | |
| Excessive | >0.25 | 0 | 0 | 0 | 0 |
| High | 0.17-0.24 | 1 | 1 | 0 | 0 |
| Optimal | <0.16 | 9 | 9 | 10 | 10 |

[z]/See reference 2 and Materials and Methods.

[y]/Sodium deficieny has not been demonstrated in citrus. Due to that only optimal, high, and excessive ranges are listed (see reference 2).

**Table 2.** Number of citrus orchards, out of a total of 10 grapefruit and 10 orange orchards sampled, classified by ranges of concentrations of leaf micronutrients in Hidalgo County, Texas in the year following the December 1983 freeze. (Leaves were collected from the same orchards in August and October.)

| Element | | Number of orchards | | | |
|---|---|---|---|---|---|
| Leaf concentration range | | Grapefruit | | Orange | |
| (ppm dry weight)[z] | | August | October | August | October |
| Iron | | | | | |
| Excessive | >250 | 0 | 0 | 0 | 0 |
| High | 130-200 | 0 | 0 | 0 | 0 |
| Optimal | 60-120 | 8 | 7 | 10 | 10 |
| Low | 36-59 | 2 | 3 | 0 | 0 |
| Deficient | <36 | 0 | 0 | 0 | 0 |
| Zinc | | | | | |
| Excessive | >300 | 0 | 0 | 0 | 0 |
| High | 110-200 | 0 | 0 | 0 | 0 |
| Optimal | 25-100 | 0 | 0 | 0 | 0 |
| Low | 16-24 | 3 | 6 | 0 | 0 |
| Deficient | <16 | 7 | 4 | 10 | 10 |
| Manganese | | | | | |
| Excessive | >1000 | 0 | 0 | 0 | 0 |
| High | 300-500 | 0 | 0 | 0 | 0 |
| Optimal | 25-200 | 6 | 6 | 5 | 9 |
| Low | 16-24 | 4 | 4 | 5 | 1 |
| Deficient | <16 | 0 | 0 | 0 | 0 |
| Copper | | | | | |
| Excessive | >22 | 0 | 0 | 0 | 0 |
| High | 17-22 | 0 | 0 | 0 | 0 |
| Optimal | 50-16 | 10 | 10 | 10 | 6 |
| Low | 3.6-4.9 | 0 | 0 | 0 | 4 |
| Deficient | <3.6 | 0 | 0 | 0 | 0 |

[z]/See reference 2.

Deficiency symptoms of Fe, Zn, and Mn and inadequate leaf levels of those elements have been observed before in Valley orchards (4,11,13). Consequently, it is not clear whether the freeze contributed to the development of deficiency levels. No clear relationship was found between severity of freeze damage and Fe, Zn, and Cu nutritional levels. Grapefruit and orange orchards developed deficient or low Zn concentrations in the leaves irrespective of the severity of freeze damage. However, the occurrence of Zn deficiency symptoms (mottle leaf) was generally more common in orchards with extensive freeze damage. In one grapefruit and one orange orchard, which had the lowest index of freeze damage, no mottle was observed despite deficient concentrations of Zn in the leaves. This would indicate that factor(s) other than Zn leaf concentration could also be involved in the occurrence of deficiency symptoms of this element. It supports previous findings of Chapman (1) who reported orchards with 10-12 ppm Zn in dry matter of leaves which showed no mottle.

The orchards with the two highest indexes of freeze damage were associated with low leaf Mn levels (Fig. 1). It is not clear whether severity of freeze damage influenced Mn nutrition, or vice-versa. Microelements have been implicated in citrus cold hardiness (7,8) but experiments in Texas failed to provide supporting evidence (14).

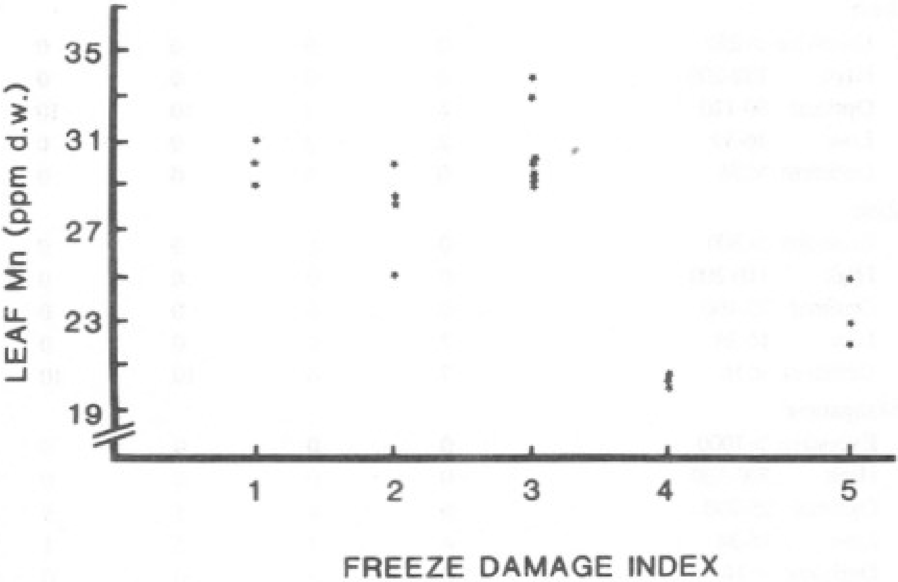


**Fig. 1.** Relationship between freeze damage in grapefruit and orange orchards and leaf Mn level in the year following the December 1983 freeze. (The higher index value the more severe freeze damage.)

These results indicate that the 1983 freeze had no deliterious effect on macronutrient nutrition of citrus trees during the first year of recovery. Deficient or low levels of Fe, Zn, and Cu were found in various numbers of the samples, but no apparent relationship existed between severity of freeze damage and Fe, Zn, and Cu leaf concentrations. However, low Mn nutritional ranges were associated with orchards having the two highest freeze damage indexes. Further studies are needed to clearify the nature of this relationship.

**Foliar Spray Experiment.** Leaf data revealed that before the experiment started trees were at an optimal nutritional level for N, but low in Fe, Zn and Mn.

Urea sprays alone significantly increased leaf N concentrations compared to the control (Table 3). No such effect was observed when urea was sprayed in combination with microelements. Apparently, the presence of microelements in the urea solution had a negative effect on urea absorption by the leaves. Sprays with microelements significantly increased leaf Fe, Mn, and Zn concentrations (Table 3). Presence of urea in the microelement spray solution diminished an increase in leaf Fe compared to that obtained when the microelements were applied alone, but accentuated increases in leaf Mn (Table 3). The later phenomenon supports findings of Labanauskas and Puffer (3).

**Table 3.** The effect of urea and micronutrient sprays on leaf mineral composition and the increase in crown height of 'Ruby Red' grapefruit trees.

| Treatment | Leaf composition (d.w.)$^z$ N % | Fe ppm | Mn ppm | Zn ppm | Increase in crown height (cm) |
|---|---|---|---|---|---|
| Control | 2.5 | 59 | 23 | 19 | 57 |
| Urea | 2.7 | 64 | 24 | 20 | 69 |
| Fe + Mn + Zn | 2.5 | 134 | 66 | 62 | 79 |
| Fe + Mn + Zn + Urea | 2.5 | 99 | 77 | 65 | 83 |
| LSD 0.05 | 0.1 | 22 | 8 | 11 | 16 |

$^z$/d.w.—dry weight.

As compared to the control, the crown height significantly increased when trees were sprayed with microelements alone or in combination with urea (Table 3). Increase in tree diameter, another measure of tree vegetative growth, was not significantly affected by any treatment (data not shown), indicating that the effect of microelement sprays on vegetative growth was rather slight.

This experiment demonstrated that small growth increases can result from combined Fe, Zn, and Mn sprays applied to grapefruit insufficiently supplied with these elements. No such responses can be expected when nitrogen (urea) sprays are applied to grapefruit trees optimally supplied with this element.

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# Sanitary Growing Practices Eliminate Soil-Borne Diseases

P.F. Colbaugh
Texas Agricultural Experiment Station
Texas A&M University Research and Extension Center

## ABSTRACT

Commercial greenhouse operations are becoming larger and more efficient to maximize production capabilities and minimize costs associated with expensive container growing methods. As a result, cropping systems for individual plants are very large with high expectations for quality products and efficiency in their production. Soil-borne fungal diseases are among the most significant problems affecting cropping efficiency and quality of greenhouse products. Various types of root and stem rotting diseases contribute to higher production costs, unpredictable growth, and reductions in plant quality. Familiarity and use of sanitary growing practices is necessary for controlling soil-borne diseases. The growing medium, container, the plant used for production and cultural operations are potential avenues of entry for soil-borne pathogens into the crop production cycle. Sanitary production practices can be effectively used to el*minate soil-borne pathogens from greenhouse production programs provided the procedures are uniformly adopted for all facets of the growing operation.

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## ORGANIZE FOR SUCCESS

The Dewey Decimal System, AT&T, and Hughes Tool Company are excellent examples of organizational strength. All have developed a systematic approach to handling their operational affairs. The strength of the respective systems is obvious. Others use the same system because it works, or if a product is involved, success can be measured by corporate profits in the marketplace. All large companies have operational sytems that are used for production of products, routine business operations and systems for marketing. The systems approach to any business gives operational stability from year to year, gives confidence to employees carrying out the organizational plan, and serves as an operational guideline for pinpointing areas for improvement.

In the commercial production of plants, as with any corporate enterprise, one of the first questions asked from successful leaders in the industry is--"What is your System?" The reason this popular question is asked is because the System of Operation is the principle business framework. We all live by one system or another and they largely measure our performance. In the production of plants, the system of production would seem to be the most important aspect of any commercial operation. In consideration of most plant pathogens, the use of carefully planned systems of production result in far greater control of persistent disease problems. In fact, systems of production largely dictate the incidence and severity of most greenhouse and nursery diseases.

The recognition factor is a major obstacle in dealing with plant pathogenic organisms. Damaging effects of most plant pathogenic organisms is seldom seen at an early stage of disease development. In most instances, we find ourselves trying to overcome problems that have already developed--that's not good business. With nutritional problems or with many types of insect problems growers have a good deal of time to make appropriate decisions to overcome the problems they cause. With plant diseases, there is only one way to prevent their damaging effects and that is through the development of an organized system of sanitation designed to eliminate the disease factor from the plant production cycle.

## SANITATION AND THE GROWING MEDIUM

The growing medium is an important source of soil-borne pathogens in the production of greenhouse and nursery crops. Use of a wide range of growing media for commercial production of ornamental plants has generally prevented efforts to adopt standard growing media for most types of plant production. While most plants can be grown in a wide variety of growing media, only a few are suitable for the purpose of sanitation (1). Production strategies for commercial crops should insure initially low populations of soil-borne pathogens in growing media at the time the growing cycle is initiated. Experience has shown that high populations of soil-borne pathogens are difficult to control by applications of chemical measures following the initiation of the growing cycle. When populations of soil-borne pathogens such as *Pythium, Phytophthora, Rhizoctonia* or *Fusarium* spp. are initially high in the growing medium, greater amounts of active ingredient in chemical drenches are required for suppression of disease activity. With few exceptions, applications of harsh chemical treatments necessary to overcome the problem result in delayed crop growth and are not effective for complete eradication of pathogens.

Production of plants in growing media containing soil or other constituents with initially high populations of soil-borne pathogens requires a supplemental program of sanitation before the growing cycle can be initiated. Applications of steam heat or fumigants such as methyl bromide or chloropicrin are often employed to eliminate or reduce populations of soil-borne pathogens prior to planting. A microbiological vacuum created by the biologically destructive action of steam or fumigants is partially overcome by the use of aerated steam for treatment of growing media (1). Media pasteurization with aerated steam (160°F, 30 minutes) leaves many beneficial microorganisms capable of suppressing root disease activity by soil-borne pathogens. Re-use of growing media for propagation beds or for container growing is always a dangerous production practice because of the presence of high populations of soil-borne pathogens. All re-used growing media and containers should be exposed to heat or chemical fumigants before the planting operation to avoid severe root disease problems.

Soil-borne diseases can be reduced by careful selection and handling of growing media prior to the planting operation. In recent years, commercial greenhouse producers have relied heavily on soilless potting mixtures as a method of reducing soil-borne disease problems. Several commercial potting mixtures are formulated with media constituents containing low levels of soil-borne pathogens. Mixtures containing commercial peat moss, perlite, vermiculite, styrofoam, calcined clay, volcanic rock or washed san can also be prepared for use as soilless potting mixtures that contain initially low populations of soil-borne pathogens. Grower experience has shown that the use of soilless potting mixtures cannot completely overcome the problem of soil-borne diseases without the use of additional sanitary precautions during the cropping cycle. Applications of soil fungicides at the time of planting have been effectively used to maintain sanitary growing conditions where soil-borne pathogen populations are initially low.

## LIMITED AVAILABILITY OF DISEASE-FREE PLANTING MATERIALS

Limited availability of disease-free planting materials for production of ornamental crops is a major problem in the plant growing industry and particularly for greenhouse production. Large-scale production of crops generally cannot insure supplies of disease-free liners because of the volume required for commercial crops. Lengthy periods required to produce rooted cuttings or seedlings for the finishing stage of growth increase the opportunity for root infection to occur prior to the planting operation. The importation of pre-finished planting materials from distant sources has also resulted in variable degrees of plant health. In perspective, most growers should assume all disease-sensitive planting materials are infected to one degree or another with soil-borne pathogens at the time of planting. Soaking planting materials is not commonly used for treatment because of the dangers of injury to plants by high temperatures required to kill plant pathogens. A variety of chemical sanitation tools are widely used for direct treatment of planting materials or as drenching agents for sanitation during the cropping cycle (3).

## SOIL FUNGICIDES-ANALOGOUS TO "TERM INSURANCE"

Over sixty soil fungicides, bactericides, and combinations of drenches or soaks are available to commercial growers for use in soil-borne disease control programs. The selection of chemicals and strategy for their effective use has been a problem to commercial growers for many years. Chemical products differ in the types of pathogens they control, formulations, rates to apply, and frequency of application necessary to perform satisfactorily. When used properly, chemical control measures can be thought of as short-term crop insurance with predictable expiration dates. When used improperly chemical diseases control measures have limited effectiveness as problem-solving tools.

Strategies of disease control involving the use of soil fungicides should be based on an understanding of the limitations of their use. Applications of soil fungicides are most effectively used as sanitation tools in overcoming low populations of soil-borne pathogens. Soil fungicides can be effectively employed for disease control in many types of soilless potting mixtures or as supplemental sanitation tools following preplanting media treatment with various types of steam or fumigants. Proper use of soil fungicides for control of soil-borne disease problems requires the presence of the chemical in the growing medium or on the plant surface at the beginning of the growing cycle (2). Periodic drenching may be required as a supplemental sanitation tool to maintain vigorous and healthy roots during the growth of the crop. The rationale for use of chemical disease control measures in this manner is based on the fact that root and stem rotting diseases cannot be controlled readily once they appear. Chemical applications are effective for preventing infection by soil-borne pathogens, not as curative measures for disease control.

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# Grapefruit Response to Freeze Simulated by Chemical Defoliation and Pruning[1]

C.L. Wiegand and W.A. Swanson
Soil Scientist and Biological Technician, respectively,
Soil and Water Conservation Research
ARS, USDA, Weslaco, TX 78596

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## ABSTRACT

Fruit yield and size, trunk circumference, and diameter of ten tagged regrowth shoots per tree of grapefruit (*Citrus paradisi,* Macf. c.v. 'Ruby Red') were followed for four years after application of the following treatments to 13 year old trees: untreated control; defoliation of the leaves with a herbicide, Broadside® ; and, all limbs pruned to 2-, 4-, and 10-cm diameter wood, respectively. Yield (Mg/ha) and number of fruit per tree differed ($P = 0.05$) among treatments for the first three years but not in the fourth. Weight per fruit and annual tree circumference increase (growth) differed among treatments only in the first year. The fourth year trees pruned to 2- and 4-cm wood outyielded the control trees. The herbicide defoliated the trees and killed the twigs back to 1 cm wood and fruit production recovered intermediate between trees pruned to 2 and 4 cm diameter wood. We conclude that pruning to 2 cm wood affects production in that crop and one more year, pruning to 4 cm wood reduces production for two more years, and pruning to 10 cm wood reduces production for at least three additional crop years. Physiological damage by natural freezes appears to add one additional year of recovery time to those reported here for physical removal of tissue by pruning. The nontranslocatable herbicide used damaged trees so similarly to historic freezes (retention of nonabscised leaves, and tissue desiccation and necrosis) that it and others should be further investigated for simulating freeze damage.

Freezes are a hazard in all major citrus production areas of the U.S. (3). Haddock (7) defined severe freezes as those in which the fruit and leaves are frozen and limbs from one to two inches in diameter are killed; such freezes have occurred over most of the Lower Rio Grande Valley of Texas in 1930, 1949, 1951, 1962, 1973, and 1983. The probability is 50% that a winter extreme minimum temperature of 20°F. will occur at Weslaco, Texas, once in 10 years (7).

[1]Received for publication 23 July 1984. Trade and company names are given for information only, and do not infer endorsement or preference by the U.S. Department of Agriculture over others that may be available.

Many factors including: cultivar; tree age; whether freezes are radiational or convective; temperature minimums and durations; site exposure; tree vigor; tree dormancy; rootstock; and other peculiarities of the weather preceding, during, and after the freeze determine the extent of damage (3,5,12,17,20,23,24,25). The uniqueness of biotic and abiotic conditions associated with individual freezes complicates comparisons among freezes and prompted the use of laboratory and field portable freeze chambers (2,18) to control minimum temperatures achieved, rates of cooling, durations, and seasonal timing of simulated freezes.

Cooper et al. (3) and Young and Peynado (24) estimated the percentage of limbs per tree in 0.6, 1.2, 2.5, 5.0, 7.6, and 10.2 cm (1/4-, 1/2-, 1-, 2-, 3-, and 4-inch) diameter categories that were killed and used them to arrive at damage ratings expressed as diameter of wood for which half the branches had been killed. For 'Valencia' orange, the tree age (years) and wood diameter (cm), respectively, for which 50% mortality occurred for the January 9 to 12, 1962, Texas freeze were: 4-5, 8.1, 5-6, 7.9, 6-7, 8.6, 12-15, 4.1, and 30-33, 5.3. The 30-33 year-old trees that survived the 1951 freeze were weakened by wood rot compared with 12- to 15-year old trees (25). Most old trees were removed following the 1962 freeze (24, 3). Peynado et al. (19) reported that the 1962 freeze killed three to seven year-old 'Valencia' orange and 'Red Blush' grapefruit to wood 3.8 to 6.3 cm (1-1/2 to 2-1/2 inches) in diameter. The 1949 Texas freeze killed the bark in the main crotch of most trees seven years old or younger (20).

For less severe freezes, foliage loss and fruit dehy'ration or deterioration within 10 days after a freeze indicate freeze severity and juice loss (5). Percentage leaf loss was proportional to percentage of frozen sections in the stem end of grapefruit but not for oranges, and fruit set was related to the amount of leaf and wood injury for the whole tree, not individual branches. For trees transplanted to the field for less than one year, Maxwell (15) used five categories of damage: (1) partial defoliation, (2) defoliation with no wood damage, (3) defoliation with small twigs killed, (4) defoliation with wood up to 1.3 cm killed, and (5) top killed back to the soil bank.

In this study trees were chemically or mechanically pruned to simulate freeze damage in order to create a controlled condition in which tree recovery in terms of fruit production, fruit size, and trunk growth could be studied. Trees are usually pruned following severe freezes to rejuvenate old trees; to improve trees access for spraying, harvesting, and other operations; to reduce crowding; and to remove dead and damaged branches (1,4,8,11,13, 14,16).

## MATERIALS AND METHODS

**Experiment design.** The experiment was conducted in a 13-year-old planting in which 'Ruby Red' grapefruit trees were spaced 4.7 m (15 ft.) apart in E-W rows 6.7 m (22 ft.) apart with a nine-year history of individual tree yields. The treatments were: 1) control (CON); 2) chemical defoliation (DL); 3) pruned of all wood smaller than 2 cm diameter (P2); 4) pruned of all wood smaller than 4 cm diameter (P4); and 5) pruned of all wood smaller than 10 cm diameter (P10). There were three replications of each treatment with the replicates consisting of the two interior trees of 12-tree plots consisting of three trees in a row across four rows. Since tree branches were interpenetrating within rows, the east and west sides, respectively, of trees adjacent to the test trees were treated the same as test trees in those rows. Tree prunings were stacked by replication for air-drying and weighed after nine months.

The treatments were applied between February 21 and March 6, 1978, after all trees had been cultured uniformly for two years. For the chemical defoliation treatment, 3.8 liters (1 gal) of Broadside (cacodylic acid [hydroxydimethylarsine] plus MSMA [monosodium methanearsonate]) was dissolved in 174 liters (46 gal) of water and the foliage was drenched. Tree growth and fruit production observations were made for four harvests. During those four years, all treatments were irrigated when 60% of the available water was depleted from the surface 3 ft of soil in the control treatment (Wiegand and Swanson, 28); the trees were fertilized annually with 1.5 lbs N per tree in later winter; a clean till culture was maintained by use of Krovar I (40% bromocil, 5-bromo-3-sec-butyl-6-methyluracil and 40% diuron,N'- (3, 4-dichlorophenyl)-N, N-dimethylurea) at the rate of 2 lb/ac a.i. in the spring and 3 lb/ac a.i. of Princep (sumazine, 2-chloro-4, 6-bis (ethylamino)-s-triazine) in the fall. Five to 6 insecticide applications per year were used to control rust mites, mealybugs, white flies and other arthropods when populations reached levels at which control is recommended.

**Tree growth and fruit production observations.** The fruit produced by each treated tree was picked each year in January, counted, sized, and weighed. Trunk circumference was measured annually in December at distance 23 cm above ground level where a narrow white stripe had been painted around each trunk. Growth flushes were noted as they occurred and basal diameters of 10 tagged regrowth shoots per tree were measured annually in March beginning in 1979. Ground photographs were taken March 9 and October 20, 1978; on May 8, 1980, and on March 25, 1981. Low altitude aerial photographs were taken on March 10, 1978.

**Statistics.** Analysis of variance (AOV) was applied to the treatment means of the various observations for individual years, and Duncan's multiple range (DMR) test was used at the 0.05 significance level to separate yearly means across treatments.

## RESULTS AND DISCUSSION

Although intended only to defoliate the trees, the bromocil plus diuron applied resulted in dieback of twigs to 1 cm wood. Although most of the bud-bearing wood was removed, or killed (DL), by the treatments imposed, the treated trees produced a sparse bloom two weeks later in 1978 than the control trees (Table 1). By the third year of the experiment, all treatments produced the same number of growth flushes, whereas for the first two years, the pruned trees produced at least one more flush of growth than the control trees.

The basal diameter of regrowth shoots was larger the more severely the trees were pruned initially (Fig. 1). After four years, the regrowth shoots more closely approached the prepruning size of the limbs where pruning was less severe. Regrowth shoots were not thinned and the number of shoots or branches per tree was greater than prior to pruning. Consequently, the regrowth shoots asymptotically approach a diameter smaller than the size of the branches removed. After the first year, the regrowth curves are parallel for the P2 and P4 treatments indicating that the shoots were increasing in diameter at a similar rate.

**Table 1.** Date of full bloom for bloom years 1978 through 1981 and number of growth flushes by treatment each calendar year.

| Year | Full bloom date | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | CON | DL | P2 | P4 | P10 |
| | | No. growth flushes | | | | |
| 1978 | March 28 (CON)<br>April 13, (P & DL) | 4 | 4 | 5 | 8 | 8 |
| 1979 | March 19 | 5 | 6 | 6 | 6 | 7 |
| 1980 | March 29 | 4 | 4 | 4 | 4 | 4 |
| 1981 | March 13 | 4 | 4 | 4 | 4 | 4 |

Virtually continuous growth in May and June; flushes indistinctive.

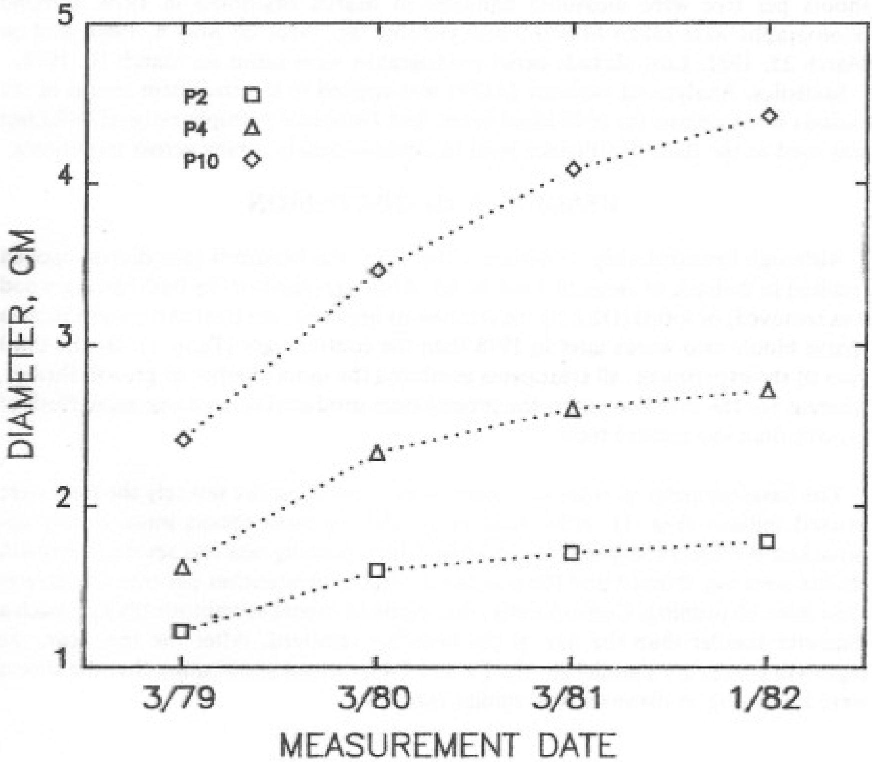


**Fig. 1.** Average basal diameter (cm) of regrowth shoots at yearly intervals after experiment initiation.

Average weight of wood removed in pruning, as measured after nine months of air drying, was 40, 66, and 116 Kg/tree, respectively, for the trees pruned to 2-, 4-, and 10-cm wood. Pruning to 10-cm wood corresponds to "scaffold" pruning and the 2-and 4-cm diameter wood pruning resulted in tree appearance similar to the "skeletonized" pruning described by Kretchman and Krezdorn (13).

Figure 2 presents the fruit production in megagrams per hectare (Mg/ha) for four seasons following treatment as well as for the two seasons preceding treatment when cultural practices were the same as during the experiment. The data are presented by the year of bloom as in Table 1 so that the data associated with 1978 are understood to refer to the 1978-79 crop year. The yields of the trees the two seasons before treatment were not significantly different among the treatment trees whereas they differed at the 0.001 probability level the first year, at 0.05 for the next two years, and were non-significant by the 4th year. The pruned trees followed a consistent pattern with lower yield associated with more severe pruning. By the third year, however, it is apparent that the CON, DL, P2 and P4 treatments are yielding alike and the P10 treatment accounts for the significant difference in yield. The physiological damage done by defoliation which killed twigs to 1 cm diameter was more detrimental to yield than pruning to 2 and 4 cm wood in the first year. These effects carried over to the second year when the yields were intermediate between those for the P4 and P2 treatments.

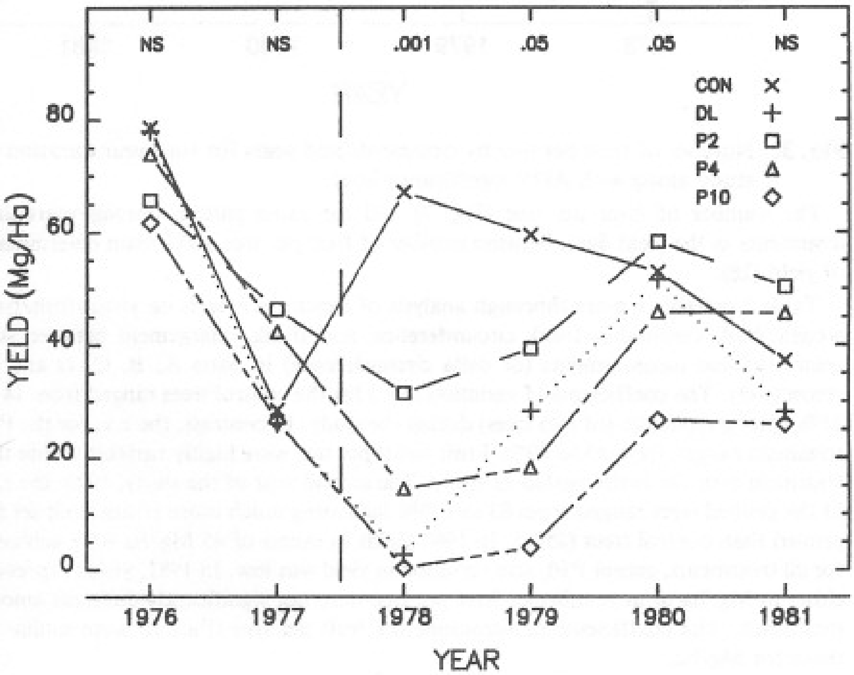


**Fig. 2.** Yield of fruit (Mg/ha) by treatments for two years prior to experiment initiation and for four years after experiment initiation with significance given for AOV each year.

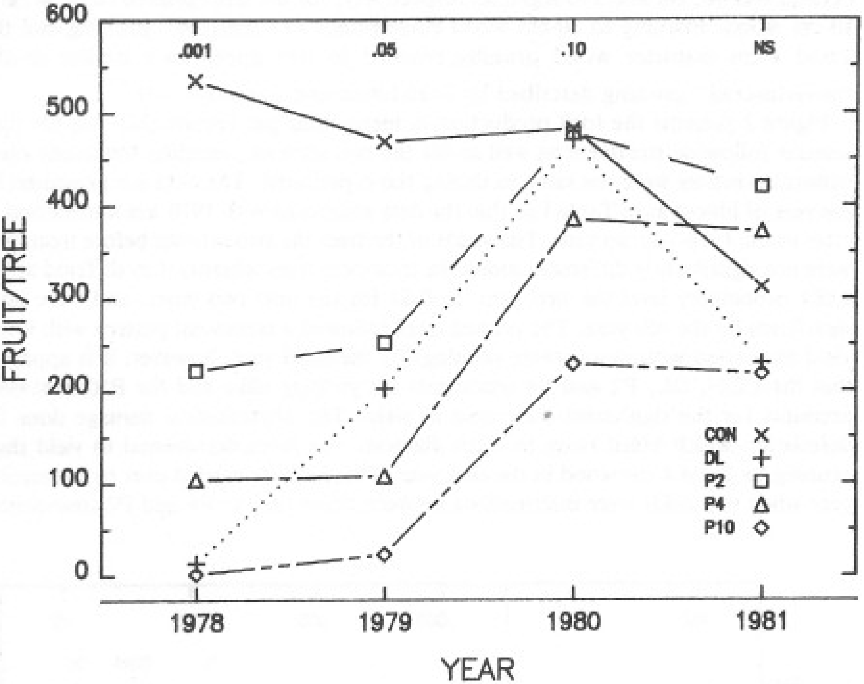


**Fig. 3.** Number of fruit per tree by treatments and years for four year duration of study along with AOV significance level.

The number of fruit per tree (Fig. 3) had the same pattern among years and treatments as the yield data, because number of fruit per tree is the main determinant of yield (28).

Table 2 presents a more thorough analysis of treatment effects on yield, fruit/tree, weight/fruit, cumulative trunk circumference, and trunk enlargement between successive annual measurements (or delta circumference) in parts A, B, C, D and E, respectively. The coefficients of variation (c.v.) for the control trees ranged from 14 to 25% among replicates (of two trees) during the study. In contrast, the c.v. for the P10 treatment ranged from 43 to 80%. Fruit yields per tree were highly variable within this treatment over the entire period of study. The second year of the study, 1979, the c.v. of the pruned trees ranged from 63 to 109% indicating much more erratic fruit set for pruned than control trees (25%). In 1980 yields in excess of 45 Mg/ha were achieved for all treatments, except P10, and variation in yield was low. In 1981, yields expressed either as Mg/ha or as number of fruit per tree were not significantly different among treatments. The coefficients of variations for fruit per tree (Part B) were similar to those for Mg/ha.

Weight per fruit differed among treatments only the year of experiment initiation (Table 2). Weight per fruit depended more on number of fruit per tree than on treatment (Fig. 4). The distribution of data points in Fig. 4 shows, however, that fruit were considerably smaller for a given number of fruit per tree in 1980 than in 1979, and that the other two years are intermediate.

Fucik and Norwine (6) have shown that final fruit size is highly correlated with temperature and insolation during the prebloom and early fruit set period, January through April. Wiegand and Swanson (29) hypothesized that the number of cells formed in the fruit control fruit size over and above ambient aerial and soil water conditions during fruit enlargement.

The yearly means of trunk circumference differed statistically each of the four years of the experiment (Table 2) as the trees grew from a circumference of 73.5 cm in 1978 to 80.5 cm in 1981. However, because of tree to tree variation, differences among treatments were not significant in any year.

In terms of annual increase in circumference, or delta circumference, treatments differed at the 0.10 level the year of initiation of the study but not thereafter. The low increase in 1980 (1.7 cm) was probably associated with the heavy fruit load that year. The heavy fruit load of the control trees in 1978 also evidently kept trunk enlargement (2.8 cm) well below those of the DL (3.8 cm) and P2 (3.1 cm) which re-established top growth rapidly but had low fruit loads. The low trunk enlargement of the P10 trees in 1978 then would be associated with the small tops the first year from a relatively low number of regrowth shoots. The herbicide-damaged trees of this study retained their leaves and had a strikingly similar photographic appearance to trees naturally damaged in historic freezes. Evidently the desiccation and tissue death effects were analogous to those produced by natural freezes of like severity. This suggests the future use of non-translocatable herbicides to simulate freeze damage. Damage the year of experiment initiation was as devastating as pruning to 10 cm and for the following two years yields were intermediate between those of the P2 and P4 treatments.

In this study, the effects on yields of pruning to 2 cm wood lasted one year, the DL and P4 effects persisted for two years, and pruning to 10 cm wood lasted the 4 years of the study. Cooper et al. (3) estimated that the 1962 freeze that killed wood of 20-year-old 'Valencia' to 13 cm would affect yields for 5 to 8 years. Our findings tend to confirm that estimate. Physiological damage in addition to the physical removal of tissue, as in pruning, appears to add an additional year to the recovery time.

## ACKNOWLEDGEMENT

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**Table 2A.** Yield treatment means, coefficients of variation, AOV significance by individual years and Duncan multiple range tests by treatments and years.

| YEAR | | CON | DL | P2 | P4 | P10 | Signif. level | Yearly means |
|---|---|---|---|---|---|---|---|---|
| | | Mg/ha | | | | | w/i year | |
| 1978 | Mean | 67.2 | 2.7 | 31.4 | 14.4 | 0.4 | .001 | 23.2c |
| | c.v.(%) | 17.5 | 41.8 | 23.3 | 43.0 | 57.9 | | |
| 1979 | Mean | 59.5 | 28.2 | 39.3 | 18.2 | 3.9 | .05 | 29.8bc |
| | c.v. (%) | 25.1 | 28.7 | 62.8 | 108.6 | 80.1 | | |
| 1980 | Mean | 52.9 | 51.5 | 58.2 | 45.8 | 26.5 | .05 | 47.0a |
| | c.v. (%) | 13.9 | 14.7 | 17.4 | 9.9 | 43.5 | | |
| 1981 | Mean | 37.2 | 28.1 | 50.2 | 45.6 | 25.9 | NS | 37.4b |
| | c.v. (%) | 17.5 | 24.1 | 45.6 | .8 | 47.5 | | |
| Treat. means | | 54.2a | 27.6c | 44.8b | 31.0c | 14.2d | .01 | |

**Table 2B.** Fruit/tree treatment means, coefficients of variation, AOV significance by individual years and Duncan multiple range tests by treatments and years.

| YEAR | | CON | DL | P2 | P4 | P10 | Signif. level | Yearly means |
|---|---|---|---|---|---|---|---|---|
| | | No. of Fruit | | | | | w/i year | |
| 1978 | Mean | 535.0 | 13.7 | 221.7 | 104.0 | 2.0 | .001 | 175.3c |
| | c.v.(%) | 23.9 | 42.1 | 24.0 | 31.5 | 50.0 | | |
| 1979 | Mean | 468.7 | 201.7 | 251.5 | 107.0 | 23.0 | .050 | 210.4c |
| | c.v. (%) | 40.9 | 32.8 | 66.2 | 107.2 | 78.4 | | |
| 1980 | Mean | 482.5 | 470.3 | 478.0 | 384.7 | 228.2 | .050 | 408.7a |
| | c.v. (%) | 11.0 | 20.0 | 26.6 | 5.3 | 42.3 | | |
| 1981 | Mean | 311.5 | 229.5 | 419.8 | 371.8 | 217.8 | NS | 310.1b |
| | c.v. (%) | 17.4 | 32.0 | 51.6 | 10.6 | 62.2 | | |
| Treat. means | | 449.4a | 228.8c | 342.8b | 241.9c | 177.8d | .001 | |

**Table 2C.** Weight/Fruit treatment means, coefficients of variation, AOV significance by individual years and Duncan multiple range tests by treatments and years.

| YEAR | | CON | DL | P2 | P4 | P10 | Signif. level | Yearly means |
|---|---|---|---|---|---|---|---|---|
| | | --------- | --------- | gms | --------- | --------- | w/i year | |
| 1978 | Mean | 409.5 | 631.5 | 460.8 | 436.8 | 531.7 | .001 | 494.1a |
| | c.v.(%) | 7.5 | 1.9 | 15.5 | 11.5 | 20.4 | | |
| 1979 | Mean | 426.2 | 456.2 | 537.8 | 543.9 | 500.3 | NS | 494.9a |
| | c.v. (%) | 14.4 | 6.6 | 16.7 | 7.6 | 25.1 | | |
| 1980 | Mean | 353.0 | 356.0 | 399.2 | 384.2 | 379.9 | NS | 373.1b |
| | c.v. (%) | 3.9 | 6.4 | 9.4 | 10.8 | 1.8 | | |
| 1981 | Mean | 385.6 | 401.2 | 401.9 | 398.2 | 404.5 | NS | 398.3b |
| | c.v. (%) | 3.4 | 8.6 | 11.2 | 10.4 | 13.9 | | |
| Treat. means | | 339.6 | 461.3 | 450.0 | 440.8 | 452.4 | NS | |

**Table 2D.** Trunk Circumference, Cumulative treatment means, coefficients of variation, AOV significance by individual years and Duncan multiple range tests by treatments and years.

| YEAR | | CON | DL | P2 | P4 | P10 | Signif. level | Yearly means |
|---|---|---|---|---|---|---|---|---|
| | | --------- | --------- | cm | --------- | --------- | w/i year | |
| 1978 | Mean | 75.9 | 73.4 | 71.5 | 73.7 | 73.4 | NS | 73.5d |
| | c.v.(%) | 3.4 | 2.4 | 1.9 | 6.3 | 3.1 | | |
| 1979 | Mean | 78.7 | 76.8 | 74.6 | 77.3 | 75.8 | NS | 76.6c |
| | c.v. (%) | 3.8 | 2.4 | 2.0 | 5.7 | 2.7 | | |
| 1980 | Mean | 80.2 | 78.6 | 76.4 | 78.9 | 77.3 | NS | 78.3b |
| | c.v. (%) | 3.7 | 2.2 | 2.1 | 5.9 | 2.7 | | |
| 1981 | Mean | 82.6 | 81.0 | 78.9 | 80.6 | 79.3 | NS | 80.5a |
| | c.v. (%) | 3.6 | 2.2 | 2.4 | 5.1 | 2.6 | | |
| Treat. means | | 79.3 | 77.5 | 75.4 | 77.6 | 76.5 | NS | |

**Table 2E.** Trunk Circumference, Delta treatment means, coefficients of variation, AOV significance by individual years and Duncan multiple range tests by treatments and years.

| YEAR | | CON | DL | P2 | P4 | P10 | Signif. level | Yearly means |
|---|---|---|---|---|---|---|---|---|
| | | ---------- | ---------- | cm | ---------- | ---------- | w/i year | |
| 1978 | Mean | 2.8 | 3.8 | 3.1 | 2.8 | 1.9 | .10 | 2.9a |
| | c.v.(%) | 14.3 | 2.6 | 12.1 | 19.9 | 57.0 | | |
| 1979 | Mean | 2.8 | 3.4 | 3.1 | 3.6 | 2.4 | NS | 3.1a |
| | c.v. (%) | 28.3 | 10.6 | 14.1 | 6.5 | 30.0 | | |
| 1980 | Mean | 1.6 | 1.8 | 1.8 | 1.7 | 1.4 | NS | 1.7c |
| | c.v. (%) | 13.3 | 23.6 | 17.5 | 18.3 | 28.2 | | |
| 1981 | Mean | 2.3 | 2.4 | 2.5 | 1.6 | 2.0 | NS | 2.2b |
| | c.v. (%) | 8.9 | 2.4 | 13.0 | 46.0 | 31.2 | | |
| Treat. means | | 2.4b | 2.9a | 2.6ab | 2.4b | 1.9c | .001 | |

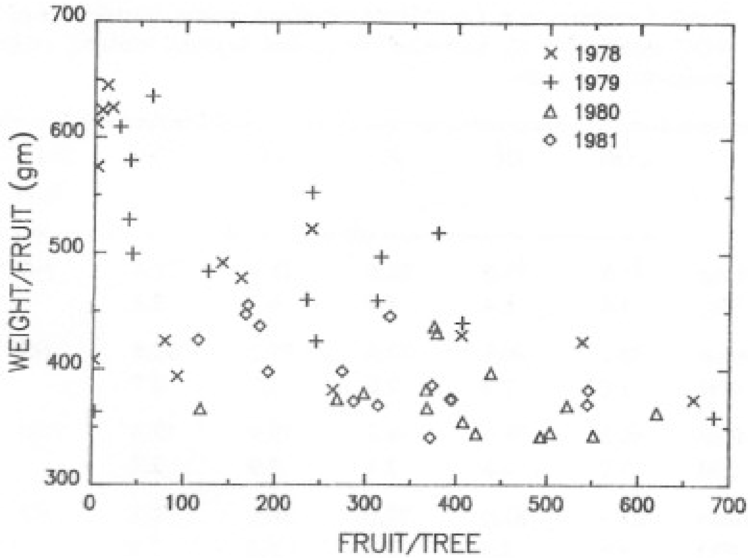


**Fig. 4** Fruit weight (gm/fruit) by replication for each individual year of the experiment.

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## 'Rio Red', a New Grapefruit with a Deep-Red Color

Richard A. Hensz
Director, Texas A&I University Citrus Center
Weslaco, TX 78596

## ABSTRACT

'Rio Red', is a recently released red grapefruit cultivar with flesh color comparable to that of the 'Star Ruby' and peel color and blush similar to the 'Ray Ruby'. It was developed in a variety improvement program at the Texas A&I University Citrus Center. The origin of 'Rio Red' was from a seedling of 'Ruby Red' followed by a radiation induced mutation and a natural mutation. Budwood of the 'Rio Red' was first released to Rio Grande Valley nurserymen in the summer of 1984..

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Seeds of 'Ruby Red' grapefruit (*C. paradisi* Macf.) (5) were planted in 1953 and 1400 of the seedlings were propagated on sour orange rootstock and planted for further observation. The better-producing trees in this planting, assumed to be of nucellar origin and with fruit horticulturally similar to 'Ruby Red', were selected for propagation in 1959 to a larger planting. In 1963, budwood out of this second planting was irradiated with either thermal neutrons or X-rays at the Brookhaven National Laboratories, Long Island, N.Y. The budwood was then propagated on sour orange rootstock (2). A tree grown from budwood irradiated with thermal neutrons produced fruit with flesh three times redder than the 'Ruby Red'. In 1971 this tree, designated A&I-1-48, was propagated and ten trees placed in a cultivar test planting. A natural mutation was discovered in 1976 (4) on a limb of one of the A&I-1-48 trees. This mutation produced fruit with flesh color five times redder than the 'Ruby Red', twice as red as the 'Ray Ruby' (3) and nearly as red as 'Star Ruby' (1) (Table 1). Peel color was similar to the 'Ray Ruby', having more-intense red blushes and cast than the peel of 'Ruby Red'. This new cultivar was named 'Rio Red' in 1984.

A planting totaling over 800 'Rio Reds' was established at the Texas A&I Citrus Center during the 1979-80 winter. Another 475 'Rio Reds' were added to this planting in November 1980. These trees grew rapidly, indicating residual nucellar vigor. Stem growth was long, producing trees with an open structure. This open growth characteristic is in contrast to the compact, tight, bushy growth of the 'Star Ruby'. Young trees have not shown the foot rot susceptibility and herbicide sensitivity observed in the 'Star Ruby'. The cambium cells of 'Rio Red' do not have the red color that is characteristic in the 'Star Ruby' when the bark is peeled back from the wood. Other characteristics of the tree and fruit are similar to 'Ruby Red' and 'Ray Ruby'. Flesh texture, sugar and acid content are similar to 'Ruby Red' and 'Ray Ruby'.

**Table 1.** Comparison of lycopene (red color pigment) content in the juice of four grapefruit cultivars grown on sour orange rootstock. Means for two seasons.

| Cultivar | Dec. | Jan. | Mar. |
|---|---|---|---|
| Ruby Red | .13 | .12 | .07 |
| Ray Ruby | .37 | .32 | .32 |
| Rio Red | .68 | .60 | .56 |
| Star Ruby | .79 | .68 | .68 |

The planting established in 1979-80, flowered and set fruit in 1981. Fruit was harvested from 400 four-year-old trees during the week following the December 1983 freeze and the average yield was 150 lbs per tree. The yield from 330 of the three-year-old trees harvested at the same time averaged 50 lbs per tree. The trees survived the freeze, although the tops were frozen to the crotch and/or trunk.

Budwood of the 'Rio Red' was first released to Rio Grande Valley nurserymen in the summer of 1984.

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## ON THE COVER

**Early stages of rebuilding: citrus in The Rio Grande Valley pruned to remove dead wood caused by freezing temperatures in December, 1983.** ***Photo courtesy of Texas A&I Citrus Center.***