JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 28, 1974

ORCHARD HEATER DISPLAY-1920

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Published by

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

P. O. Box 107, Weslaco, Texas 78596

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Aims and Objectives of the Society

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

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

The Society has sponsored 28 annual Institutes, where outstanding speakers from all parts of the country present new developments in the field of horticulture. Panel discussions, social get-togethers and a barbeque round up the all-day program.

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

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

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Dr. Rafael H. Cintron

Recipient of the Arthur T. Potts Award 1973

Dr. Rafael H. Cintron was named recipient of the Arthur T. Potts Award for 1973 at the Rio Grande Valley Horticultural Society's Annual Meeting.

Dr. Cintron was born in Mayaguez, Puerto Rico, December 19, 1908. He was graduated from the College of Agriculture, University of Puerto Rico in 1932 and obtained a Master of Science Degree and Doctor of Philosophy Degree from Texas A&M University in horticulture.

His horticulture career started in 1932 as horticulturist and plant breeder with the Puerto Rico Department of Agriculture and from 1934-1944 taught courses in tropical fruit production at the Agricultural University of Puerto Rico. After obtaining his Ph. D. degree in horticulture from Texas A&M University in 1946 he joined the Hoblitzelle Foundation in the Rio Grande Valley of Texas where, for the following 26 years, as Horticulturist and Director of Research in tropical and sub-tropical fruit, he planned, conducted and directed research and implemented programs in all phases of citrus production. Since 1972 Dr. Cintron has been acting as an advisor and lecturer in tropical and sub-tropical horticulture to Texas A&M University and as a citrus specialist to the United States Agency for International Development (USAID).

For many years, he served as Chairman of the Citrus Sub-committee of the Texas A&M University Agricultural Research Advisory Committee and as Texas representative on the National USDA Citrus Advisory Committee reviewing all research work at the national level. While Chairman of the Citrus Subcommittee, Dr. Cintron was responsible for the initiation of a market research program. Part of his many accomplishments in the Rio Grande Valley were to help organize and be a member of the Board of Directors of Texas Citrus Mutual and of the Texas Citrus Marketing Committee and has acted several times as consultant on citrus research to USAID in Latin America. Dr. Cintron also did extensive research with papaya culture in the Valley and has been actively engaged in the development of a Texas avocado industry and research program.

Dr. Cintron is an active member of the Rio Grande Valley Horticultural Society. He has worked in many capacities in the Society including President and Director for several branches of the Society. He is also a member of many other professional societies including American Society for Horticultural Sciences, the California Avocado Society and the Gamma Sigma Delta Honor Society.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY
PATRON AND SUSTAINING MEMBERSHIP, 1974

The RGV Horticultural Society gratefully acknowledges the support of its Patron and Sustaining Members, which makes the publication of the Journal possible. These members are also recognized for their outstanding contributions to the horticulture industry of the Valley.

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Rio Grande Valley Horticultural Society
January 22, 1974

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RGV Horticultural Society

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Drip Irrigation. . . . . Dr. Falih K. Aljibury, Area Technologist, Agricultural Research and Extension Center, Parlier, California

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A Complete Victory Over
Purple Scale on Texas
Citrus with an Introduced Parasite. . . . . Herb Dean, Associate Profesor, Texas A&M University, Experiment Station, Weslaco

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Entomologist, Texas Department of Agriculture, Austin

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P.E., Director, Texas Occupational Safety Board, Austin

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Grande Valley. . . . . Mr. Paul W. Leeper,
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Station, Weslaco

Mechanical Citrus Harvesting. . . . . Mr. Ronald W. Droll,
Research Associate, Texas A&M University – Experiment
Station, Weslaco

Current Mechanical Vegetable
Harvesting Research. . . . . Mr. Ray E. Armstrong,
Associate Professor, Texas A&M University – Experiment
Station, Weslaco

EVENING SESSION: Dr. John Fucik – Presiding

Floratam – A new St. Augustine
Decline Resistant Variety of
St. Augustine Grass for Texas . . . . Dr. Robert W. Toler,
Associate Professor, Virologist, Department of Plant
Sciences, Texas A&M University, College Station, Texas

Current Turf Research in Texas . . . . Dr. Richard L. Duble,
Assistant Professor, Department of Soil & Crop Sciences,
Texas A&M University, College Station, Texas

"For All To See"
Floral Designs and Arrangements . . . . Mrs. G. Browning Smith,
President, Texas Garden Clubs, Harlingen, Texas

TALKS PRESENTED AT THE 28th ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Citrus Abscission Chemicals

W. C. Wilson

Assoc. Plant Physiologist
Florida Dept. of Citrus
Agr. Res. and Educ. Center, IFAS
Lake Alfred, FLA 33850

Cycloheximide (CHI or Acti-Aid) is now cleared by FDA (EPA) for use on oranges for processing in Florida. On the whole it gives good fruit loosening, but adverse weather conditions can reduce its effectiveness. CHI cannot be used on citrus trees after the advent of the spring growth flush, but limited successes have been achieved with 'Valencia' during the summer period. Some limited trials with Ethephon have been conducted on tangerines, tangelos and oranges for fresh fruit use, and some successes have been noted. A new compound (ABG 3030) is currently under test for loosening oranges. This compound effectively loosened 'Valencia' oranges without harming young growth, blooms or green (immature) fruit, but often caused unacceptable peel injury, particularly on early and midseason oranges. The Florida Department of Citrus has screened several thousand compounds for abscission activity during the past 6 years.

Better Yields with New Citrus Rootstocks

Heinz K. Wutscher

Research Horticulturist
Subtropical Texas Area
Southern Region
ARS USDA
Weslaco, TX 78596

Several citrus rootstock tests at locations in the center of the Lower Rio Grande Valley have shown that trees on Citrumelo C.P.B. 4475, Morton and Troyer citrange outyield trees on sour orange by substantial margins. Overall Citrumelo C.P.B. 4475 is the best rootstock because of resistance of tristeza, exocortis and xyloporosis viruses, better salt tolerance, and excellent resistance to footrot. Fruit from trees on this rootstock is usually larger than fruit from trees on sour orange; total soluble solids are often, but not always, lower than in fruit of trees on sour orange but the differences are usually less than 1%. It appears that citrus production in the Rio Grande Valley could be made more profitable by use of Citrumelo C.P.B. 4475 rootstock.

Mechanical Citrus Harvesting

Ronald W. Droll

Research Associate
Texas A&M Univ. Expt. Sta.
Weslaco, TX 78596

Mechanical citrus harvesting includes two areas of interest: mechanical assists for pickers and complete mechanical harvest of the crop. Mechanical assists include orchard transports, pallet box dumpers and man positioners. An analysis of the currently available man positioners in California will be discussed.

Complete mechanical harvest includes removing the fruit from the trees and delivering it to the over the road transport by all mechanical means. Acti - Aid is still the major abscission chemical in use. Fruit is currently removed by shakers, air blasts and water gun and windrowed with steel tined, brush type and rubber finger type sweepers. Picking the fruit from the windrow is done with the FMC Load - All or the TAMU Experimental Machine. The TAMU Experimental Machine includes low pressure reel, cupped pickup elevator, elevator, oppose motion cleaner, and hydraulic hopper trailer.

'Floratam' A New St. Augustine Decline Resistant Variety of St. Augustine grass for Texas

Robert W. Toler

Professor
Dept. of Plant Sciences
Texas A&M Univ.
College Station, TX 77843

A new disease of St. Augustinegrass was observed in South Texas in 1966. The disease was found to be caused by a mechanically transmitted virus and named St. Augustine Decline (SAD). Purification, electron microscopy, and serology revealed the virus to be related to Panicum Mosaic Virus and was designated the St. Augustine Decline strain of Panicum Mosaic Virus (PMV-SAD). The development of SAD resistant varieties of St. Augustinegrass offered the most promising method of control. Techniques were developed for inoculation in the greenhouse and screening of St. Augustine accession for SAD resistance began in 1968. Field testing of the materials showing resistance in the greenhouse was initiated in 1969. In the field trials the susceptible Common cultivar became infected and St. Augustine Decline disease developed in 30 to 180 days. Roselawn strains and a Florida selection FA110 remained symptomless. The Florida selection FA110 was named Floratam. Floratam is a moderately coarse-textured fast growing dark green grass that is a selection of FA-23. It is a deep rooted, stoloniferous St. Augustine that is resistant to SAD and compares favorably in growth with Roselawn and Common. In trials at College Station, Texas, Floratam and all other available varieties of St. Augustinegrass were evaluated for resistance to the southern lawn chinch bug. Floratam and one experimental selection resisted chinch bug injury. Floratam was named jointly by the Texas Agricultural Experiment Station and the Florida Agricultural Experiment Station and approved for release to certified growers in these states in 1972. The grass was made available to homeowners in 1973. Foundation Floratam sod is available through the Texas Agricultural Experiment Station Foundation Seed Service, College Station, Texas.

Current Turf Research in Texas

Richard L. Duble

Asst. Prof.
Dept. of Soil and Crop Sciences
Texas A&M Univ.
College Station, TX 77843

Turf research projects at Texas A&M University are primarily concerned with the establishment and culture of the hybrid bermudagrasses and St. Augustinegrasses. For lawn turf the hybrid bermudagrasses are best established by sprigging at a rate of 5 bushels per 1,000 square feet (1 bushel of sprigs may be obtained by shredding 1 square yard of sod). Tifway, Tiflawn, Tifgreen and Texturf-10 bermudagrasses are ideal for high quality turf. Fertilization practices should include application of a complete fertilizer such as 13- 13- 13 in the spring and fall with supplemental nitrogen during the summer. Foliar applications of ferrous sulfate at 2 oz/1,000 square feet are also required at frequent intervals to prevent yellowing from iron chlorosis. The hybrid bermudagrasses should be mowed at a height of 1 inch or less with a reel-type mower that has 6 or more blades per reel.

St. Augustinegrass may be established in about 3 months by planting 4-inch plugs on 2-foot centers. Faster establishment may be obtained by planting on 1-foot centers, but requires 4 times as much planting stock. Fertilization is the key to rapid establishment. Bi-weekly applications of a nitrogen fertilizer at a rate of 1 pound of nitrogen per 1,000 square feet (3 pounds of ammonium nitrate, 2 pounds of urea or 5 pounds of ammonium sulfate per 1,000 square feet) will produce a rapid cover. After the lawn is covered, fertilization may be reduced to spring and fall applications with frequent applications of ferrous sulfate for iron chlorosis.

Thatch accumulation is a problem in St. Augustinegrass and hybrid bermudagrasses. Reducing fertility rates in established turf, heavy, infrequent watering (in contrast to light, frequent watering) occasional vertical mowing (dethatching) and limited use of pesticides all help to reduce thatch accumulation. Turf that has a thick layer of thatch is difficult to mow, repels water, encourages insect and disease problems and results in more winter damage in lawns. When this conditions exists renovation including dethatching, aerification and adding topsoil will help to revitalize the lawn.

The Texas Citrus Virus Picture

L. W. Timmer

Assoc. Prof., Texas A&I Univ. Citrus Center
Weslaco, TX 78596

Talk presented to the Annual Institute of the Rio Grande Valley Horticultural Society January 22, 1974.

Texas has not experienced the catastrophic losses to virus diseases which have occurred in other citrus areas. Millions of trees on sour orange rootstock were lost to tristeza in Brazil, Argentina and California and, when these areas changed to tristeza-resistant rootstocks, they encountered problems with exocortis and cachexia. At present, tristeza is becoming a serious problem in Florida and in Spain. Psorosis has caused significant tree losses in almost all citrus areas. Stubborn and greening, diseases caused by mycoplasma, are factors limiting citrus production in California, South Africa, and parts of Asia. Young tree decline, a disease of unknown cause, has devastated some orchards in Florida. With the exception of some loss of production due to psorosis, Texas has not experienced serious problems with viral diseases. Presently, fungal and nematodal diseases probably cause greater damage than do viral diseases. We are fortunate to have escaped serious damage in the past, but problems may be encountered in the future. Active programs should be initiated to assure that the Texas industry will continue to be free of significant virus disease problems.

Herein, I will describe the symptoms and characteristics of potentially important budwood-transmitted diseases and the methods used to detect them. I will describe the situation in Texas with regard to each disease and will suggest some measures which can be taken to avoid losses from virus diseases.

CHARACTERISTICS OF VIRUS AND VIRUS-LIKE DISEASES

Psorosis. Psorosis, or scaly bark, is presumed to be caused by a virus, but the pathogen has never been isolated or purified. It causes bark scaling and decline of mature citrus trees and severely reduces production 4-5 years after the appearance of bark lesions. Bark lesions (Fig. 1) do not appear until trees are at least 6 years old and commonly not until they are 12-15 years old. Trees with bark lesions may also have twig lesions, chlorotic spots on mature leaves, and fruit symptoms. Flecking on young leaves is the only symptom which appears on infected trees prior to the development of bark lesions. The primary means of spread of psorosis is by the use of infected buds for the propagation of new trees. Psorosis can be transmitted through the seed of some citranges [*Poncirus trifoliata* (L.) Raf. x *Citrus sinensis* (L.) Osb.] or rarely by root grafts (2, 17). Psorosis or related diseases are spreading naturally by unknown means in some citrus areas (16, 22). Psorosis virus infects almost all varieties of citrus causing severe bark scaling on sweet oranges (*C. sinensis*) and grapefruit (*C. paradisi* Macf.), but no scaling on lemons [*C. limon* (L.) Burm. f.].

Tristeza. The tristeza virus is an extremely long, flexuous, rod-shaped virus (1), which causes a severe tree decline especially of sweet orange on sour orange (*C. aurantium* L.) rootstock. Affected trees first wilt slightly, the foliage becomes light colored, and trees decline slowly and become unproductive. Affected trees often bear heavy crops of small fruit which color prematurely. Occasionally, tristeza-infected trees may collapse and die within a week or two. Although sweet oranges on sour orange rootstock are the most severely affected, other varieties on sour orange are also affected. Other susceptible rootstocks include grapefruit, alemow (*C. macrophylla Wester*), acid lemons, some tangelos

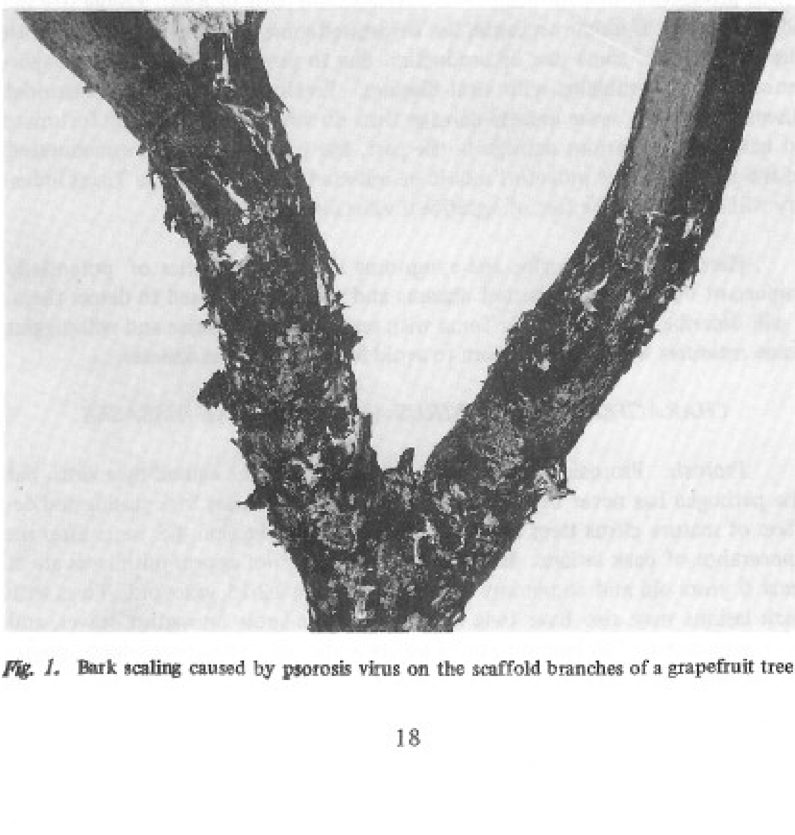

Fig. 1. Bark scaling caused by psorosis virus on the scaffold branches of a grapefruit tree.

(*C. reticulata* Blanco x *C. paradisi*) and shaddocks [*C. grandis* (L.) Osb.] Rootstocks which are resistant to tristeza in most areas are Rough lemon (*C. limon*), Cleopatra mandarin (*C. reticulata*), Rangpur lime (*C. reticulata* var. *austera* hybrid), Troyer citrange, trifoliate orange (*P. trifoliata*) and sweet orange. The disease is spread by the use of infected budwood and by aphids. The black citrus aphid [*Toxoptera citracidus* (Kirk.)] is the most efficient vector, but the coffee aphid [*Toxoptera aurantii* (B. de Fonsc.)], the cotton aphid (*Aphis gossypii* Glover), and the green citrus aphid (*Aphis spiraecola* Patch.) are also able to transmit this virus.

Exocortis. Exocortis is caused by a very small virus or viroid (19), which produces stunting and bark scaling of certain citrus varieties. Trifoliate orange. many trifoliate hybrids, and Rangpur lime are severely affected, but tree size may be reduced on some other rootstocks. Exocortis affects tree size on sour orange only slightly if at all. The disease is some often spread by use of infected budwood, but may also be carried on budding knives, clippers, hedging machines, and other tools. (9).

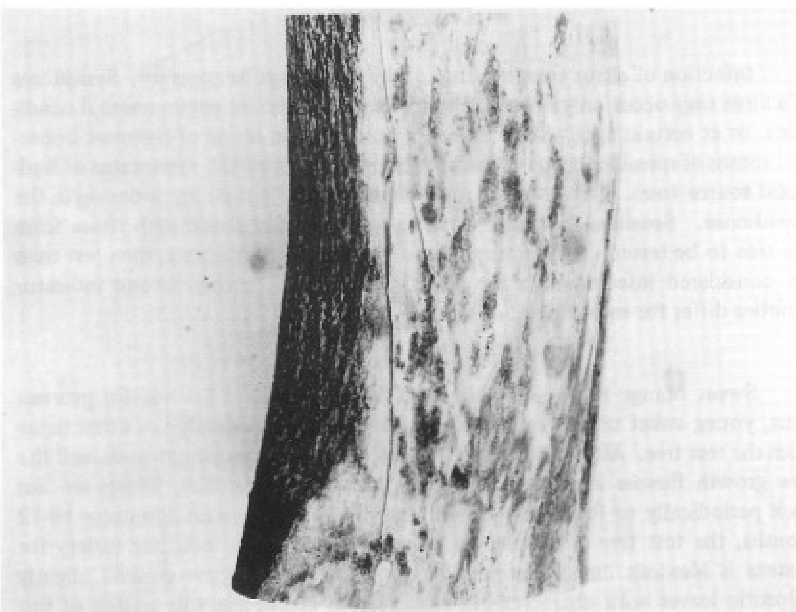

Fig. 2. **Pitting and gum deposition produced by cachexia virus beneath the bark on the trunk of an Orlando tangelo tree.**

Cachexia. Cachexia, or xyloporosis, is presumed to be caused by a virus, but no pathogen has been isolated or identified. Pits, pegs and gum impregnation appear in the bark and wood near the budunion on susceptible varieties (Fig. 2). Severely affected trees are stunted and usually decline and become unproductive. Orlando tangelo is very susceptible to the disease and many tangelos, many tangors (*C. reticulata x C. sinensis*), alemow, some tangerines, and most sweet limes [*C. aurantifolia* (Christm.) Swing.] are affected. The only known means of spread of the disease is by the use of infected budwood.

Stubborn. Stubborn disease is caused by a mycoplasma rather than a virus (10), but is also budwood-transmissible. Stubborn trees are often dwarfed and unproductive with small, misshapen fruit. Seed abortion is common in seedy varieties and leaves are usually small, mottled, and have an upright growth habit. The disease affects almost all varieties of citrus, but is not usually as severe on lemons as on other species. In California, stubborn is spread by the beef leafhopper, *Circulifer tenellus* (Baker) (12) and similar diseases in Africa and Asia are spread by the citrus psyllids, *Trioza erytreae* (Del Guercio) and *Diaphorina citri* Kuw. (3, 13).

DETECTION

Infection of citrus trees by viruses may not always be apparent. Symptoms of a virus may occur only in certain varieties, under certain environmental conditions, or at certain ages. Since budwood transmission is one of the most important means of spread of citrus viruses, it is essential to know the virus status of budwood source trees. Detection of most citrus viruses is done by indexing in the greenhouse. Sensitive indicator varieties are graft inoculated with tissue from the tree to be tested. If symptoms appear in the indicator plants, then test trees are considered infected with the virus in question. Procedures and indicator varieties differ for each virus (5, 11).

Sweet orange is the indicator variety for psorosis. To test for psorosis virus, young sweet orange seedlings are grafted with bark patches or other tissue from the test tree. After the grafts have taken, the seedlings are cut back, and the new growth flushes inspected for flecking symptoms (Fig. 3a). Plants are cut back periodically to force new growth and if no symptoms are found for 10-12 months, the test tree is assumed to be psorosis-free. The indicator variety for tristeza is Mexican lime (*C. aurantifolia*). Infected limes have cupped, slightly chlorotic leaves with characteristic vein-clearing symptoms and pitting of the wood (Fig. 4a, b). The test procedure for tristeza is essentially the same as for psorosis.

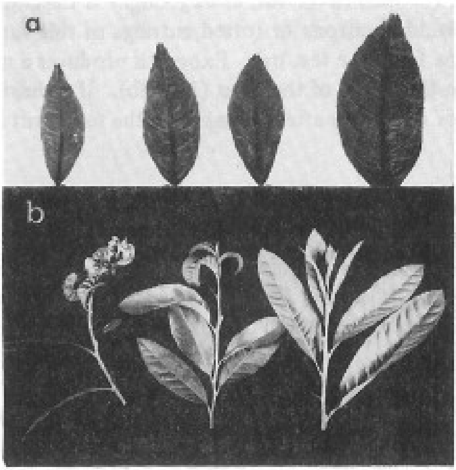

Fig. 3. Symptoms of psorosis and exocortis on sensitive indicator varieties. a) flecking symptoms on the young leaves of sweet orange seedlings infected with psorosis virus b) leaf curl of exocortis-infected Etrog citron: left) severe strain, center) mild strain, right) healthy citron.

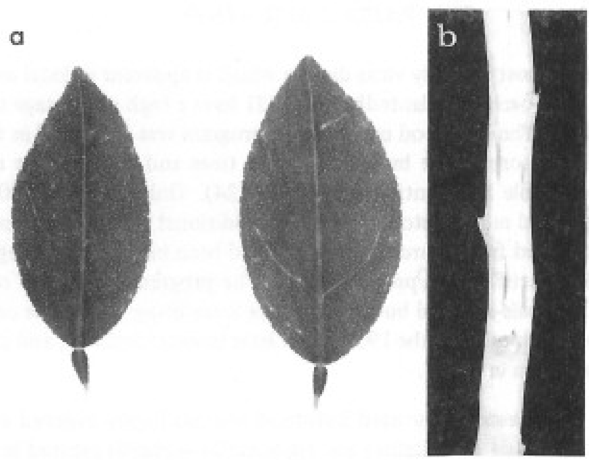

Fig. 4. Tristeza symptoms on Mexican lime, the indicator variety for this virus: a) vein-clearing on young leaves b) stem-pitting in the wood of a young seedling.

Etrog citron (*C. medica* L. var. *ethrog* Engl.) is the indicator variety for exocortis virus. Budded citrons or rotted cuttings of this variety are graft inoculated with tissue from the test tree. Exocortis produces a mild to severe leaf curl, depending on the strain of the virus (Fig. 3b). If indicator plants do not show symptoms for 6 months after inoculation, the test plant is considered free of exocortis.

Detection of cachexia requires a long-term test on seedlings or budded trees of Orlando tangelo. Trees infected with severe strains of the virus show pits, pegs and gum deposition in 1-2 years, but 5-6 years are required to be sure trees are free of the virus. Recently, Parson's Special Mandarin was found to be a more sensitive indicator (18) and the time required to index for cachexia should be reduced considerably.

Madam Vinous sweet orange, Sexton tangelo, Cuban shaddock, and some other varieties may be used as indicators for stubborn. Since the stubborn mycoplasma is poorly distributed in tissue and symptoms are sometimes mild, indexing for stubborn requires more indicator plants for each test than other diseases. Indicator seedlings are side-grafted with twigs from the test tree, and after the grafts have taken, a single shoot is forced on each indicator seedling. Stubborn-affected shoots are stunted, have small, cupped leaves which may be chlorotic or mottled.

THE VALLEY SITUATION

Psorosis is almost the only virus disease which is apparent in local commercial orchards. Most orchards planted before 1951 have a high percentage of trees with bark lesions. The budwood certification program was instituted in the late 1940's to register psorosis-free budwood source trees and psorosis-free nursery stock became available for planting about 1951 (24). Only about 200,000 trees were sold as certified nursery stock. However, additional millions of uncertified trees were propagated from source trees which had been inspected and registered by the budwood certification program (20). The program effectively reduced the number of psorosis-infected budwood source trees being used. The certification program was active during the 1950's, but later interest declined, and presently there is no program in effect.

Most of the commercially used budwood sources I have indexed are free of psorosis, but psorosis bark lesions are apparent in orchards planted in recent years by major nurserymen. These psorosis-infected trees may come from sources which were originally registered as psorosis-free, but which were, in fact, infected. Since source trees in the certification program were selected on the basis of field and nursery inspection and were never indexed (23), it is possible that a few infected trees were registered as psorosis-free. The presence of psorosis in young orchards may also be due to accidental mixing of psorosis-free budwood and budwood from uncertified, infected trees.

Psorosis and a strain of citrus ringspot virus (CRSV) may be spreading naturally in this area (22). I have found trees of nucellar origin, which were presumably virus-free, that have psorosis bark lesions. Several trees from nucellar selections of Hudson grapefruit have been found to be infected with CRSV. CRSV is closely related to psorosis, but may not cause bark lesions as psorosis does. The manner in which these trees became infected is not known, but the budwood parents are free from the virus. At present, the spread of psorosis and CRSV seems to be limited and may not be of economic significance, but care should be taken that no budwood source trees become infected.

In the Valley, we have faced a potential tristeza epidemic for many years. Virtually all of our trees are on sour orange rootstock which is susceptible to tristeza. The virus is present in many ornamental Meyer lemon trees (14). The Rickett's Meyer lemon, which was introduced from Florida about 1930 (8) was indexed and released as a tristeza-free variety in 1961 (21). Presumably the Meyer lemons propagated since then are free of the virus, but it is possible that infected trees are still being used as budwood sources. Two of the aphid vectors of the virus, the green citrus and the cotton aphid, are present here, but we do not have the most efficient vector, the black citrus aphid. In spite of the presence of the virus, the vector, and a susceptible host plant, tristeza had not spread in this area. There may be many reasons for this. Meyer lemons are located mostly in backyards and not in commercial orchards, which makes spread less likely. A high percentage of the trees in the Valley are grapefruit which is not a preferred host for aphids. The most probable reason that spread has not occurred is that a strain of aphid capable of transmitting the virus is not present here. Dean and Olson (6) were unable to transmit the virus using local aphids. Tristeza probably will not start spreading in the Valley until a strain of the aphid capable of transmission arises. There is no way to predict when this might occur. Suffice it to say that tristeza is spreading in virtually every other citrus area in the world.

Exocortis and cachexia viruses are present in most old-line grapefruit and oranges (15). As long as we use sour orange rootstock, these viruses should not cause problems in grapefruit or oranges. Should we change to an exocortis-susceptible rootstock such as trifoliate orange or many of its hybrids, or to a cachexia-susceptible rootstock like sweet lime, virus-free budwood will be essential. Star Ruby grapefruit and most other nucellar grapefruit and orange selections are free of exocortis and cachexia. Although not a problem on grapefruit and oranges, cachexia has caused serious damage to some Orlando tangelo orchards in the Valley.

Stubborn is not a significant economic problem in Texas. Carpenter (4) found symptoms of stubborn in Valley orchards in 1959. I have also found many trees with stubborn-like symptoms, but to date I have not been able to confirm the diagnosis by indexing.

CONTROL

The foundation of virus disease control in citrus is a budwood certification program. The previous program in the Valley was effective and should have been maintained in force or improved and expanded. Most of our present and potential problems can be controlled by regulatory measures.

The budwood certification program should be reestablished. Budwood sources presently used by nurserymen should be indexed and certified if free from psorosis, tristeza, and stubborn. Foundation plantings of high yielding selections of economically significant and important ornamental varieties should be established. Grapefruit and orange parent trees should be free of psorosis, tristeza, and stubborn, but should not be rejected if infected with exocortis or cachexia. However, at least one budline of each commercially important variety should be sought which is free of exocortis and cachexia in case a change in rootstock variety becomes necessary or desirable. Tangelos and other cachexia-susceptible varieties should be free of that virus, and Meyer lemons should be free of tristeza.

A certification program would eliminate budwood spread of the important citrus viruses, but some may be spreading naturally in the Valley. Certification of budwood as psorosis-free may not completely eliminate the psorosis problem as it has in other citrus areas, but the true extent of the problem of natural spread cannot be known until budwood spread of the virus ceases.

A certification program would not eliminate the possibility of a tristeza epidemic, but should gradually reduce the number of infected Meyer lemons in the area. If parent trees were indexed periodically, any spread of tristeza might be detected before it became extensive. In some areas of California where tristeza spread was detected early, quarantine and eradication programs have been successful in containing the disease (7). To substantially reduce the possibility of a tristeza epidemic, it would be necessary to eradicate infected Meyer lemons as was done in the San Joaquin and Coachella Valleys of California.

To a limited extent some of these goals are being met withoug a certification program a foundation planting of trees selected in the first certification program still exists at the Texas Agricultural Experiment Station. Although these trees have not been indexed recently, they should serve as a valuable source of propagating material. I am indexing many high yielding nucellar and old-line selections at the Texas A&I Citrus Center. A foundation planting will be established soon from these sources and budwood will be available to anyone desiring it. I routinely index Meyer lemons and declining orchard trees for tristeza and will index any trees for other viruses as time and facilities permit.

Making indexed budwood available to the citrus industry cannot take the place of a legally enforced certification program. At present, the grower has no guarantee, except for the word and the reputation of the nurseryman, as to the virus status of nursery trees. In contrast to insect and some disease problems, the buyer has no way of determining the presence or absence of viruses by inspection of the nursery stock. A certification program must assure that parent trees are initially free of harmful viruses and that they remain so. The means available for detection of citrus viruses are still crude and time-consuming compared to those used with other plant viruses. Nevertheless, there is no reason to plant an orchard with trees carrying potentially damaging viruses.

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What We Can Know About Soils — Past, Present and Future

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ABSTRACT

The future of an agricultural area depends much on what is done to the soil. This requires knowledge of the nature and behavior of the soil. The Rio Grande Valley has accumulated decades of practical soil experience. Numerous excellent research papers on various soil phases offer a wealth of facts. The practical man who has to solve the problems of the soil is always faced with the totality of the soil. The following is a bird's-eye view of Valley soil knowledge. This is by no means an exhaustive study. It is not a scientific thesis; rather it is an attempt at stressing what has not been sufficiently emphasized, at clearing up misunderstandings, at giving an idea of what is, what could be, and what ought to be in the field of soils.

THE ORIGIN OF OUR KNOWLEDGE ABOUT SOILS

Soils are the result of what nature has given and what man has done to them. Understanding of soils requires knowledge of nature and the history of man's farming activities. All aspects of nature, from dead mineral to living cell, are involved; and man's thinking about soils has changed over the centuries.

There was a time when man walked over the land picking fruit and leaves for nourishment. Then came a time when man settled down. He placed seeds into the ground and raised his own food. This happened approximately 20 thousand years ago. Man's experience in growing crops goes back to this time, and *we must never forget that this native experience is still a great factor in the attitude of a farmer towards his soil. Constant care, keen observation, and logical conclusions are still basic characteristics of a good farmer.*

Great changes came to man and soil with the industrial revolution - *the age of the machine.* Man was able to move earth with powerful machinery; to plow hundreds of acres in a short time, to pump thousands of gallons of water onto the land. But, here and there, something went wrong. Man discovered that the land could be overplowed, that the land could be overwatered; in fact, *that man could destroy the natural fertility of the soil.*

At the same time, man's thinking about soil was influenced by the *age of science.* Millions of dollars were spent for research. It was realized that soil is a complex medium involving all phases of science - physics, chemistry, bacteriology, mineralogy, and so on. Volumes upon volumes were published revealing a remarkably new insight. Mysterious notions of the past made room for scientific facts. Scientifically tabulated observations threw new light upon the behavior of soil and plants, and under the influence of advanced technology and scientific facts, a new era dawned. New, useful practices were developed.

The *fertilizer industry was born.* Crop yields increased as never expected. This was a great salvation considering the explosion of world population. The concept of man accomplishing so much by adding something to the soil, by manipulating nature to his advantage was foremost preoccupying the mind of the man who tilled the soil. Yet, there was more to it.

The soil is not a mechanical automat: add a little and you get little results, add more and you get more. The increase of crops follows biological and mathematical rules. When we fertilize, we change the soil. We supplement what Mother Nature has released as plant foods. This release varies from field to field. The fertility of the soil depends upon many factors that are not fertilizer problems. Soil fertility cannot simply be bought in the fertilizer bag. There are no cure-alls, there are no specific crop fertilizers, such as, corn fertilizer or cotton fertilizer.

In spite of all the progress, serious mistakes are still made. There are great diversities in opinions and there are sad disappointments as to crop behavior. The question is: *What is the reason for crop behavior in each case at hand?* The answer to this question is important with the food crisis appearing on the horizon. Raw materials for fertilizers are getting scarce. *We must use plant foods with much greater precision, obtaining higher yields at lower cost, plus sustaining, or even increasing, the fertility of the soil.* This is the challenge before us now. How can this be done? It is a problem of fitting proven experience and applied science into practical soil management. The age of simple recipes is over.

THE UPDATING OF THE PRACTICAL MAN'S SOIL CONCEPT

What counts is the man who makes the decision as to what should be done to the soil. He must get away from useless customary ideas and from old misconceptions and habits. Instead he must open his mind to today's new explorations in the field of soil. In spite of the enormous complexity of the soil, *a new thinking about soils must be created, showing in a simple way* *how it all functions together from the raw material soil to the finished crop.*

To the practical grower the soil is of value because of the growth that comes from it. The contact medium between soil and crop is the roots. The roots represent the intimate working together between the growing crop and the soil. (It has been shown that if all roots from a 4-month-old rye plant were lined up in one direction they would cover 385 miles.)

Roots are alive! They need air and water. Restrict one of these two necessities and roots as well as crops are affected. The membrane of the root is in contact with the solution of the soil. The composition of the soil solution is essential to the crop. It contains the needed nutrients. It is ever-changing and it is influenced by its contact with the more or less solid colloidal phase. The *colloids* are the finest chemically active parts of the soil. Together with organic material and living bacteria they represent the biodynamic life complex of the soil.

High calcium carbonate in the soil, as found in the Valley, results in alkaline soil solution. Whenever the *soil solution* is alkaline, different elements are in solution than those in an acid medium. The reaction of the soil solution influences to a great extent what the crop can get out of the soil. In addition, it is, of course, essential to consider the living character of the protein of the *root membrane.* Here lies the secret to what a specific crop can absorb from the soil and how that crop can make use of what is absorbed. The above briefly described phases of soil activity in soil-plant relationship are explored by thousands of scientists all over the earth. The grower's question is: What can be used practically on my ground here and now?

THE PRESENT STATUS OF SOIL KNOWLEDGE IN THE RIO GRANDE VALLEY

In the following we have listed a number of the more important *soil-growth factors in the Valley.* This is certainly not a complete discussion. Also, a great deal of what is said is no doubt known by many. However, many of these soil facts are *not all sufficiently understood and emphasized for practical purposes.*

Soil texture and structure. A soil fertility diagnosis which ignores the prevailing propo tions of sand, silt, and clay texture is of limited vaiue. This is often overlooked. Clay is the all-powerful ingredient regulating absorption and exchange of chemical compounds. Amount and kind of clay play a role in the release or lock-up of nutrients. Clay affects greatly the mechanical make-up of the soil mass. Some crops prefer light soils; others prefer heavier soils.

Texture below the topsoil layer deserves attention. Better or poorer permeability below affects lower root activity, leaching of nutrients, moisture reserves, irrigation water penetration (irrigation practices). Mechanical qualities of profile layers are of special importance in growing citrus trees. In tight, heavy clay subsoils, root systems stay shallow and less extended than in open profiles. Trees grow slower, stay smaller, and it is more difficult to produce large fruit sizes. Grapefruit are a great deal more sensitive in this respect than oranges.

The *structure of the soil* is the pattern in which the finest single clay particles are put together. We may have either large stable crumbs with large pore spaces in between or we may have a deterioration of crumb structure resulting in a compact mass. *Good structure means easier root growth with high amounts of available air and moisture.* Roots are very sensitive to the quality of soil structure. A soil of fertile structure will be able to produce high yields and will therefore use fertilizer more efficiently. On the other hand, heavy fertilizer applications on a soil of poor structure are frequently uneconomical.

The importance of structure in Valley soils is definitely not sufficiently recognized. Excess irrigation water applications are often responsible for poor structure. Working the soil when it is wet will tend to destroy its porosity. In northern regions of freezing temperatures, the ice expanding in the pore spaces will result in an open spongelike structure, noticeable particularly during the spring period. The Valley does not have such rejunevating freeze effects. Also, in regions of generally high rainfall organic matter percentage is high. High organic matter results in plentiful bacterial activity. The slimes and glues of bacterial action and dying bacteria have a great deal to do with the formation of solid crumb structure. The Valley organic matter level is relatively low. Cultural practices are inclined to reduce it further. There is, in general, over the Valley a trend toward structural decline.

Salt concentrations. Soils in a climatic region like the Valley are subject to excess soluble salt concentrations. *Effective methods to determine the effect of soluble salts on plant life have been extremely useful.* Proper salt test results answer many essential questions. In the *excess range* where plant growth is poor or no longer possible, salt readings indicate the seriousness of the problem, how long it will take to remove the excess salts, where do they come from, is drainage needed. After the installation of drain tiles, periodic checks are essential to observe progress of salt removal.

In case of trees, the salt status must be known prior to planting, not only in the surface but also in the subsoil. Young trees may do well the first few years. After this, decline may set in due to lower level salts. Salt concentrations in different soil layers of an orchard profile represent an interesting history of what has happened to the land and what might happen in the future. In mature trees, salts in lower layers of an orchard may bring about premature wilting and reduction of fruit size. The resistance of trees during adverse climatic conditions, such as, droughts, wind and freeze, is much lower where salt concentrations are high, even if present in lower layers.

Crops differ greatly in their *tolerance to salt.* This is of great practical importance and often not sufficiently considered. In a field of a certain salt excess, a bean crop may be a complete failure, while a crop of beets or Bermuda grass may show satisfactory production. No soil examination in our region should be without a salt determination, since in so many cases an increase of salts explains a drop in production. Salt reading indicate to some extent the status of soil permeability.

In case *poor well water* is used during emergency, salt check has proven to be very valuable in showing how much of the poor water can be used without damaging crop or soil.

Nitrogen. More can be done with nitrogen applications than with any other nutrient. Nitrogen is the essential part of protein and indispensable to all life. Nitrogen in the soil is unstable. It occurs in many different forms; possibly more than 95% of the total nitrogen is present in organic form. Only a very small part, 3%, is changed by bacterial action during the year into ammonia and nitrates. Roots are able to absorb nitrogen in these two forms. In the Rio Grande Valley, ammonia is very rapidly changed by bacterial action into nitrates due to the presence of high calcium and high temperatures. Bacterial activity, soil type, organic matter, moisture and temperature are factors upon which the availability of nitrogen depends.

There is no direct, simple way to measure how much nitrogen is actually available in the soil. Science has, however, developed *check methods from which we can judge to some extent the nitrogen status in a piece of land.* Organic matter per cent and texture give some idea.

Nitrate tests are a useful indicator of the nitrogen balance in the soil. When nitrates are high, crops have not consumed the available supply, more than needed was produced by bacterial action, or there was a carry-over from previous nitrogen application. If nitrates are high, especially in case of young small plants, nitrogen should not be added. It may only add to undesirable excess and also is an unnecessary expense. Low nitrate test figures are not necessarily a sign of low nitrogen supplies; low nitrates can be an indication that they are being absorbed by the crop as rapidly as they are produced. This basically is healthy, yet the low nitrate test does not exclude the possibility of deficiency.

The main nitrate consumption, of course, takes place during the main growth period. At that time lack of avialable nitrogen may reduce yields. On the other hand, excess applications in certain crops could retard maturity and produce undesirable conditions during the harvest time (cotton, sugar cane).

Nitrates are rather variable. They are water soluble. In many soils they may be easily lost by leaching; in heavy soils, especially when the soil is wet for long periods, nitrates can revert to unavailable forms or be lost in form of gas.

In crops that occupy the land for longer periods - citrus trees, sugar cane - *nitrogen percentage of the leaves is a valuable indicator of the nitrogen status within the plant.* It reflects nitrogen absorption by the entire root system. It shows the nitrogen supplies in the tissues for immediate use. High, medium or low ranges and their meanings have been well established for various crops. Leaf samples must be taken from the proper part of the plant and at the proper time.

Phosphates. Phosphates act differently than nitrates. They do not move freely in the soil. Placement in relation to the growing root is therefore important. Knowledge of the root system extent and depth is desirable. Phosphate availability varies greatly in the Valley, from low, causing crop decline to high, representing reserve supplies. Phosphate availability tests, if properly conducted, are much more reliable than generally accepted.

In soils having high organic matter, phosphate availability is inclined to stay up for longer periods while in high calcium carbonate soils available phosphates are rapidly locked up. Phosphates, if applied in form of manure, are longer lasting than phosphates applied as fertilizer. The need for available phosphate varies greatly from crop to crop. This is a factor which is essential in the economy of phosphate use. It has not been sufficiently considered in the past.

Calcium carbonate - iron deficiency. Calcium carbonate - caliche - found in Valley soils deserves more attention than it gets. *Whenever calcium carbonate is very high in the surface soil, the root systems have difficulty absorbing* *iron.* This is the principal cause of the typical yellowing pattern of iron deficiency. Different types of crops are affected in a greatly different manner. Bermuda grass and spinach, for instance, are not affected; while young citrus trees and sorghum are very sensitive toward high calcium carbonates. High clay content in the soil will counteract the effect of high calcium carbonate. Iron deficiency is therefore especially common in sandy, high carbonate soils. Furthermore, excessive wetness will promote iron deficiency; so will low temperatures. Since iron moves slowly within the plant, a shortage of iron is usually noticed in younger, fast growing parts of the plant. Organic matter has favorable effects upon iron deficiency problems. Organic materials decaying in the soil will bring about formation of carbon dioxide. With the moisture of the soil, this will form carbonic acid. The acidifying effect promotes better iron uptake. This is the reason, for instance, why young orchards on high caliche soils show less iron deficiency the year after a cover crop has been disced in.

High calcium carbonate in the subsoil does not affect the uptake of iron by crops nearly as much as it does in the surface. .However, excessively high carbonates in lower layers have retarding effects on root growth and may bring about other complications. Not too much is known about this. Additional research is needed on this subject.

In general, Valley soils are of alkaline reaction due to their calcium carbonate content. There are, however, some Valley regions where the calcium carbonate is by nature relatively low, yet the native soil is alkaline. Under the influence of ammonia fertilizers and repeated irrigations, calcium reserves are reduced and the soil becomes less and less alkaline. Here and there reaction begins to turn even to the acid side. These soils are inclined to have structural problems. Flocculating effect of the calcium is obviously missing. Many of these soils, particularly when sandy, will become cement hard when dry, and root action is impeded. Crops are inclined toward premature wilting. Water penetration is much slower.

PRINCIPLES TO ARRIVE AT A MORE PERFECT KNOWLEDGE OF OUR SOILS

Proper planning of soil management is not easy. Nature plays many unexpected tricks. Here, we hit it right, and there, we commit an error. We notice symptoms, but we do not know the cause. In spite of all this, we have come a long way. With increasing experience and continuous research efforts, future planning should become more productive and reliable. In the following paragraphs, we have described a few basic principles which should be observed in diagnosing soil conditions.

Consider all soil factors (coordination - confirmation). All factors affecting plants and soil must, as much as possible, be evaluated. Soil is an enormous entity. *To understand one part, one must understand the whole.* Focusing attention, for instance, only upon nitrogen and phosphate, and ignoring salts and soil structure is wrong. Over-emphasizing a pet idea and neglecting the rest of nature's functions may lead to undesirable conclusions. The sizing up of citrus fruit, for instance, depends upon the amount of water entering the growing fruit. If this water influx is restricted, sizes will be small. The cause may be dryness of the soil, or it may be excess salt which prevents moisture from entering the roots, or it may be obstructed root development. It may also go back to damage of tree framework which limits the flow of sap.

Correlation of various soil growth factors is important. Judging one growth factor by itself may not have much meaning. What is really essential often shows up in relation to other factors. For instance, high calcium carbonate in its effect upon iron absorption is of minor importance in high clay soils. If, however, the soil is very sandy, the problem is extremely serious.

In order to *confirm findings* or assumptions, it is important to have various indications pointing in the same direction so as to create a firmer ground for what is truly happening in the soil. Leaf symptoms are useful indicators, often quite distinct, as the specific symptom for iron deficiency, salt excess, zinc deficiency. Often, however, such symptoms are not clear cut, but reflect a combination of problems. Foliage may look light green, having the appearance of nitrogen deficiency; yet, the pale color may not be caused by lack of nitrogen. It may be the result of excess wetness or some other cause.

Use ALL means leading to better soil knowledge. All means possible should be used to explore the nature of the soil. All available tools of technology and science should be employed. In the past, we have often been too one-sided, relying upon only one type of procedure or one certain test. To get the correct idea of how to examine the soil, we should take a lesson from the medical profession. The physician feels, he looks, he observes, he takes X rays, he makes tests. The same type of investigations must be used on soils.

What can we see on the crop is an indication of what the status of the soil may be. A soil analyst must know specific foliage symptoms. He must be able to recognize symptoms *not* caused by the soil (insect and disease problems).

The sense of feel in the soil diagnostic process is often underrated. The "finger" or "feel" test to determine physical soil characteristics is often considered "primitive" by experts who use complicated instruments. Yet there is no more remarkable testing equipment than the sensitive nerve endings in the finger tips. Slight differences in sandiness, in siltiness, or the glue-like stickiness of the soil in certain parts of a field could explain why plants react differently in one part than they do in another part of the field. When it comes to soil structure, there are various laboratory tests available, but none measure the *total structural condition* as it notably affects the growth of the root system. By studying the soil in the field, one can get a good idea of fluffiness or porosity on the one hand, or the compact tightness on the other hand.

What we cannot grasp directly with our senses, we must determine with the help of instruments or by tests. Such tests, like the checks for salt concentrations or for availability of nutrients, are able to give us essential insights. *What counts in these test results is their meaning to plant growth* in a certain set of conditions. This appropriate understanding is often lacking.

Much work will have to be done in the future regarding useful test procedures. There are still tests being used that are not accurate enough to reveal the true meaning in relation to soil and crop behavior. On the other hand, extreme exactness for practically applied purposes is not needed. For instance, the nitrate content of a soil may change during the day from 22 lb to 28 lb per acre due to increased bacterial action. This is of no practical importance. Exactness is needed, of course, in research work in striving for mathematically accurate correlation. The important thing in practically applied soil analysis is the essential ranges - ranges which show us what is deficient and therefore needs attention, what is medium, high or excessive. Such meaningful figures are *guide posts* showing trends and directions toward the true facts of what is going on in the soil.

Sometimes tests are performed that have no chance of showing anything useful, such as, certain minor elements that have never proven to be deficient in a particular area. For each area, a *routine essential check program* must be developed that shows all factors that could be of importance. Aside from this, *auxiliary tests* should be performed in special cases, if necessary. For instance, where well water was used in the past, gypsum requirement tests may give valuable information on mechanical damage due to sodium adsorption. We must learn *not* to do what is unessential, but learn *to do the essential with the required accuracy.*

Generalities are of limited value - individual attention is needed. Recognition of *individual soil area characteristics* is important. Soils are different in the most diversified sense of the word - from large climatically different regions to spots of special conditions in the backyard. The behavior of soil and crop responses is decidedly different from one large region to another region of different climate or soil origin. For most perfect diagnosis, *examinations and interpretations must be adjusted to each region of particular characteristics. Laboratory methods must be used which have been proven by performance records in the field.* For instance, phosphate determination by an acid extraction method gives good yield correlations in regions of acid nature. In calcarious soils like ours in the Valley, the bicarbonate of soda method has proven to be superior. We must first decide what are the best methods for local investigation. Then we must set up these methods on a production basis and, third, stick to them to get a wide field experience. Soil examination tests for one region may be unnecessary in another. For instance, potash examinations are not needed in our region because of high reserve supplies of exchangeable potash. Determinations of soil reaction are of general usefulness in acid soil areas in order to determine necessary lime applications. Generally pH determinations are of relatively little importance in most soils of our region.

The practical grower is not interested in general discussions of soil characteristics. He needs to know what the case is in this particular piece of land here and now. To determine this, *a truly representative sample is needed.* To divide even large fields for the purpose of practical sampling is not justified as long as the field is entirely uniform. On the other hand, small fields may be very different due to past treatment and management practices. Of decided importance are the *differences which occur within the same field.* Disregarding these differences can lead to serious errors. Mixing samples from areas of different characteristics is like mixing blood samples from different patients. The results have no meaning. Soil samples must be taken with understanding.

Aside from original natural differences, there are differences which are man-made. Many of them are the results of land leveling, cutting down high areas and filling low areas. In removing fertile topsoil, cuts may be made into layers of excess calcium carbonate, extremely low organic matter, or high salts. In our machine age, *there is a tendency to treat all fields alike, disregarding the areas of differences.* In the long run, this will prove to be inefficient, especially considering increasing land values. *It pays in by far most cases to bring these different areas up to the standard of the rest of the land before equal treatment is undertaken.* Often when problems show up only the poor area is sampled. It would be much more instructive to take samples from the poor area as well as the adjoining area of good growth. Such *contrast sampling* should become common practice, since it gives a much clearer picture of prevailing conditions.

In many cases *samples in different soil layers* are revealing. In case of trees, for instance, the surface soil layer may show a perfect condition while the subsoil layers suffer from excess salt. Also, a second foot sample in case of field crops may give useful information. The second foot may show a slight or a very decided drop in phosphate availability. It may show an insignificant or a high supply of nitrates due to leaching. The raised planting beds in fall. particularly in carrots, often show accumulations of excess salt in the first two inches due to excess evaporation after furrow irrigations. The uppermost two inches will show this excess which prevents seed germination. If a sample were taken down to the depth of ten inches, this upper salt excess which is detrimental to germination would not show.

The time factor is essential. Soils are always changing. *Important soil and growth characteristics may be evident at one time but not at another.* They may be visible early in the spring, but not later in the fall. Inadequacy of irrigation methods are evident in dry years but not during rainy seasons. Each year with its typical temperatures and rainfall will affect one orchard differently than another. Iron deficiency symptoms will show up on young foliage, but may not be visible three weeks later.

Nature takes her own time. We must learn to understand this. A tight or poorer soil structure usually does not develop overnight. It becomes more evident as years go on as a result of poor cultural practices. A high water table in an orchard may result in rotting off of lower roots, which may become evident only months later. Salts may show dangerous increase long before the crop is seriously affected. Land improvements do not necessarily show results overnight. It takes time to accomplish washdown of salts, improvement of lower root growth, rebuilding of organic matter in cut areas. Mistaken ideas are often the result of hurry-up judgement.

The need for objectivity is vital. It must be mentioned that our attitude toward the soil does not always give the land a square deal. *The need of the crop, the laws of nature, must be considered above all. Wherever true facts can be had, they should not be sacrificed to selfish interests. Land should be evaluated and judged in accordance with its future productive abilities.* Only such materials should be applied that have a possibility of improving soil fertility and yields in an effective manner. Pet ideas, one-sided opinions, the lust for a quick dollar, are unacceptable. The Valley's reputation, as well as its agricultural well-being, depends to a great extent upon honestly facing the facts of the land.

We have come a long way in handling our Valley soils; yet we can never know all about nature. The understanding and managing of our soils is by no means perfect. However, we can continually try to make it *more* perfect. *There should be less guessing and more factual opinions. We must continuously try to do what is better for our soils and improve our thinking about soils.* Doing and thinking and thinking and doing go together. A great American once said: "It is not enough to be industrious; so are the ants. What are you industrious about?" (Henry David Thoreau).

RESEARCH REPORTS

Onion Response to Desiccants and Ethephon

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ABSTRACT

Five chemicals were evaluated in 1970 and 1971 for potential use in preparing onions for mechanical harvesting. Paraquat (1-1'-dimethyl-4,4'-bipyridinium dichloride) at 0.5 kg/ha was the most effective chemical and uniformly desiccated onion foliage. However, bulbs did not enter dormancy and new sprouts emerged within 2 weeks after paraquat was applied. Ethephon [(2-chloroethyl) phosphonic acid], applied at 1.1, 2.2, or 4.5 kg/ha 2 weeks before harvest, did not affect onion foliage, bulbs or neck constriction before harvest.

Mechanized harvesting of vegetable crops has been inevitable due to several complex socio-economic factors affecting agricultural labor in the United States (1). Problems and procedures associated with mechanical harvesting of vegetable crops have been reviewed (6).

A mechanical harvester for onions was developed in 1950 (7) with more recent improvements (3). Onion leaves were clasped between rotating belts which lifted and carried bulbs into a topping device. The lack of uniform maturity and variation in onion desiccation were mentioned as considerations in mechanical harvesting of onion bulbs. In more recent research, harvesting was most efficient when foliage had matured but had not deteriorated. Consequently, commercial use of mechanical harvesters would be enhanced if the crop could be prepared for harvest at specific planned intervals. Earlier and more uniform mechanical harvesting and marketing schedules could be arranged if maturity and more rapid drying of foliage could be chemically promoted, as commonly practiced in harvesting potatoes.

Neo-decanonic acid (NDA) as investigated was an onion desiccant in 1968 (8). Foliar desiccation was achieved within 3 days after NDA was applied at 55 kg/ha (50 lb/acre) or more. Desiccation was limited to the tissue that was sprayed since the chemical was not translocated. However, the incidence of neck rot due to *Botrytis* spp. was three to five times higher in two of the three onion cultivars, compared to untreated controls. Successful storage of onions is dependent on proper closure of the neck to exclude pathogens from leaf scales in the bulb.

Ethephon produces ethylene and simulates endogenous ethylene production in plant tissue. Foliar application of ethephon promotes many economically important plant responses (2). Crop maturity, senescence, and (or) abscission are frequently induced or enhanced by ethephon. Levy and Kedar (4) applied ethephon when onion seedlings had four to five true leaves. Ethephon resulted in earlier bulb formation but the final size of bulbs was reduced due to growth retardation from ethephon. Early, repeated applications of ethephon reduced the growth of leaves. In laboratory trials, ethephon promoted the weakening and drying of leaves. Ethephon tends to retard onion height and suppress seedstalk development (5).

Numerous chemicals are commercially utilized for desiccation or defoliation of cotton or potato foliage before harvest. Since ametryne [2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-*s*-triazine] at 1.1 or 2.2 kg/ha, or dinoseb (2-sec-butyl-4,6-dinitrophenol) at 1.7 or 3.4 kg/ha, resulted in 20% desiccation or less on onions in preliminary trials (D. T. Smith, unpublished data), these chemicals were not included in these investigations.

The objective of this research was to investigate the feasibility of chemically enhancing natural senescence or promoting desiccation of onion foliage for mechanical harvesting.

MATERIALS AND METHODS

Five chemicals were applied preharvest in 1970 and 1971 as possible harvest aid treatments for mechanically harvested onions. All treatments were applied in 140 liters/ha of water containing 0.5% nonionic surfactant. Chemicals investigated were: paraquat at 0.5 and 1.1 kg/ha, GLC-514 (1.1'-dimethyl-4,4'-bipyridinium bistribromide, a 50% wettable powder formulation of Terr-O-Pik, Great Lakes Chemical Corp., W. Lafayette, Ind.) at 0.5 and 1.1 kg/ha, DEF (*S, S, S,*-tributylphosphorotrithioate) at 2.2 kg/ha, sodium chlorate at 3.3 kg/ha, and ethephon at 1.1, 2.2 and 4.4 kg/ha. Plots were one bed by 6 m with two rows of onion per 1 m bed.

Chemicals were applied with a tractor-mounted plot sprayer and were replicated three times in a randomized block design each year. A spray shield prevented droplets and mist from drifting to adjacent rows. Treatments were applied 11 September 1970 and 27 September 1971. Onions were 40 to 50 cm tall, with eight to ten leaves and bulbs were 8 to 10 cm in diameter. In 1970, 20 to 30% of the plants had tops down and in 1971, 50 to 60% had tops down when treated.

Desiccation and procumbency of leaves were evaluated 2 weeks after treatments were applied. The percentage of plants with desiccated and decumbent foliage was determined by visual estimates and by counting affected and unaffected plants in 3 m of row. Percentages derived by the two methods were averaged before statistical analyses since similar values were obtained by both methods. Height of new foliage and regrowth (above the bulb) was recorded.

The severity of neck rot was evaluated in 1971 in all plots since bulb decay (damage) was readily apparent. Ten bulbs in each plot were cut perpendicularly to the leaf scales to observe extent and migration of rot through the bulb. Rot severity in each bulb was evaluated as follows: none-no discoloration at the neck; moderate-rot present in the upper one-third of the bulb; severe-rot evident in the upper one-half or more of the bulb. The incidence of rot was also visually evaluated in ten bulbs from plots treated with paraquat or ethephon after 30 days of storage at 20 to 25 C.

RESULTS AND DISCUSSION

General Observations. Onions were difficult to chemically desiccate because: (a) spray interception was poor due to the erect nature of leaves; (b) the surface area of leaves was less than that of broadleaf plants; and (c) regrowth developed from untreated subterranean meristems.

Since onions were green and succulent when treated in 1970, plant desiccation was generally poor. Consequently, in 1971, treatments were applied later, after some natural death and senescence was observed. Some foliage had started to dry naturally when plants were treated in 1971, as indicated by the untreated control (Table 1).

Chemical desiccation. Paraquat was the most effective chemical of those investigated in killing onion foliage (Table 1). Desiccation increased significantly when a higher rate of paraquat was applied. However, GLC-514, which contains the same cation as paraquat, partially desiccated foliage in 1970 when applied at 1.1 kg/ha but generally was ineffective. There was no visual effect of DEF, sodium chlorate, or ethephon on onion foliage.

Sprouting. New leaves emerged from the bulbs after foliage was chemically damaged. Sprouting was most severe in 1970 when treatments were applied before natural bulb maturity was reached. (Table 1). However, in 1971, when chemicals were applied later than in 1970, sprouting still occurred where foliage was chemically killed. The rate and amount of sprouting was generally proportional to the amount of foliar desiccation. Consequently, new shoots emerged from bulbs of all plants treated with paraquat. Rainfall in the fall may have

Table 1. Desiccation and regrowth of onion leaves 2 weeks after harvest-aid chemicals were applied.[z]

		1970		*1971*	*Height of regrowth (cm)*	
Chemical	*Rate (kg/ha)*	*Desiccation (%)*	*Procumbent leaves (%)*	*Desiccated + procumbent (%)*	*1970*	*1971*
Untreated control	–	13c	14b	57bc	0.0e	1.8
Paraquat	0.5	50b	40a	74b	7.6b	4.3
	1.1	67a	43a	90a	10.2a	4.3
GLC-514	0.5	20c	20b	71bc	2.5d	3.3
	1.1	40b	23b	61bc	5.0c	1.8
DEF	2.2	22c	22b	70bc	0.0e	2.5
Sodium chlorate	3.3	15c	12b	54c	0.0e	0.8
Ethephon	1.1	17c	10b	57bc	0.0e	4.3
	2.2	13c	13b	56bc	0.8de	0.8
	4.4	20c	20b	67bc	5.8bc	1.8

[z] Means in the same column with the same or no letter are not significantly different ($P < 0.05$).

affected the amount of regrowth after treatment in both years.

Bulb decay. There was no difference in decay and internal discoloration of bulbs 2 weeks after treatments were applied in 1971 (Table 2). At harvest, 50% or more bulbs were infected with *Botyris* and were stained or discolored. Rainy weather before harvest probably enhanced the entrance of the organism through the bulb neck. Decay continued to develop after treated bulbs were stored.

After 30 days of storage, the incidence and severity of decay in bulbs from paraquat-treated plots were not different from untreated controls. In contrast, Pendergrass et al. (8) found that chemical desiccation of onions with NDA increased the incidence of decay. A possible explanation for this apparent difference was that treatments in this experiment were delayed until some natural senescence was observed (70 to 80% procumbent foliage), which may have restricted the entrance of the organism into bulbs.

Although ethephon did not visually hasten maturity, promote desiccation or influence decay at harvest, it was felt that this chemical might influence bulb condition after storage. However foliar application of ethephon, 2 weeks before harvest had no visual effect on bulbs after 30 days of storage.

Table 2. Severity of rot in onion bulbs at harvest and 30 days after storage when harvest-aid chemicals were applied in 1971.[z]

Chemical	*Rate (kg/ha)*	*At harvest*			*After storage*		
		None	*Moderate*	*Severe*	*None*	*Moderate*	*Severe*
Untreated control	-	47	40	13	10	57	33
Paraquat	0.5	50	30	20	10	63	27
	1.1	47	37	16	13	40	47
Ethephon	1.1	37	47	16	10	47	43
	2.2	37	40	23	26	37	37
	4.4	50	30	20	10	63	27

[z] There was no difference in rot severity due to treatment ($P < 0.05$).

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Distribution of Viable Weed Seeds in Soil Profiles at Various Locations in the Lower Rio Grande Valley of Texas

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ABSTRACT

Several sites of variable soil characteristics in the Lower Rio Grande Valley of Texas were selected for study of the distribution of viable weed seeds in soil profiles. Seed species and their greatest depth of germination in soil were Palmer amaranth (*Amaranthus palmeri* S. Wats.), 38 mm (1.5 inches); common purslane (*Portulaca oleracea* L.), 9 mm (0.35 inch); horse purslane (*Trianthema portulacastrum* L.), 16 mm (0.65 inch); London rocket (*Sisymbrium irio* L.), 7 mm (0.28 inch); ridgeseed spurge (*Euphorbia glyptosperma* Engelm.), 20 mm (0.79 inch); ragweed parthenium (*Parthenium hysterophorus* L.), 26 mm (1.0 inch); common sunflower (*Helianthus annuus* L.), 49 mm (1.9 inches); and junglerice (*Echinochloa colonum* (L.) Link), 73 mm (2.9 inches). The greatest depth of seed germination of several weed species occurred in soils with large clods, regardless of soil texture.

In the search for adequate soil treatments for weed control, the depth of seed germination of weeds in soil should be known to assure the placement of the control agent within the target area. The main objective of this study was to determine the germination depths of several common weed species in the cultivated agricultural soils of the Lower Rio Grande Valley of Texas. We were expecially interested in soils where vegetables were grown.

MATERIALS AND METHODS

Several sites were chosen for the study to provide a range of soil particle size, soil surface characteristics, and weed species (Table 1). Sites were chosen just after rainfall, where specific weed species had just emerged from the soil, to facilitate the location of seeds in the soil profile. Metal pans, 61 cm by 58 cm, with three sides 10.2 cm high, were horizontally inserted into the soil to 15 cm deep to sample the soil profile in four replications at each sampling location.

Table 1. Description of the field locations for soil profile analyses of seed germination of weeds.

Location		*Soil texture*[a]	*Weed species*	*Soil surface geometry*	*Soil condition*
L_1	(Weslaco)	Sandy loam	Common purslane	Flat	Loose, small clods
			London rocket	Flat	Loose, small clods
			Ragweed	Peaked beds	Packed, large clods
			Sunflower	Peaked beds	Packed, large clods
L_2	(Progreso)	Clay	Palmer amaranth	Shaped beds	Loose, small clods
			Junglerice	Shaped beds	Packed, large clods
L_3	(Progreso)	Clay loam	Junglerice	Flat	Loose, small clods
L_4	(Monte Alto)	Sandy loam	Palmer amaranth	Shaped beds	Loose, small clods
L_5	(Mission)	Clay	Junglerice	Shaped beds	Loose, large clods
			Common purslane	Shaped beds	Loose, large clods
			Ragweed	Flat	Packed, large clods
L_6	(Rio Grande City)	Sandy loam	Palmer amaranth	Flat	Loose, small clods
			Junglerice	Flat	Loose, small clods
L_7	(Rio Grande City)	Clay loam	Junglerice	Flat	Loose, large clods
			Horse purslane	Flat	Loose, large clods
			Palmer amaranth	Flat	Loose, large clods
			Sunflower	Side of river	Packed, large clods
			Spurge	Shaped beds	Packed, large clods

[a] Soil classification was determined by particle size analysis. No crop has been planted except seedling cabbage at L_4 and seedling celery at L_7 in shaped beds.

Soil samples were then transported to a laboratory, where several random subsamples, 10 cm by 10 cm each, were extracted from each replicate field sample. Soil from each subsample was then carefully washed through a 0.5-mm sieve, to expose and facilitate the measurement of the length of each seedling from the soil surface to the seed. The soil profile analysis of the distribution of viable seeds is reported as percentage of total germination at depths to 80 mm in the soil profile (Fig. 1-4). Weed species reported are Palmer amaranth, common purslane, horse purslane, London rocket, ridgeseed spurge, ragweed parthenium, wild common sunflower, and junglerice. All samples were taken from the field in September or October 1973.

RESULTS

Palmer amaranth germinated only in the surface 24 mm (1 inch) of soil, except at location 7, where large clods existed, and a small percentage of seeds germinated to 38 mm (1.5 inches) (Fig. 1). Most of the seeds germinated in the surface 10 mm (0.40 inch) in a clay (location 2) and in a sandy loam (location 4).

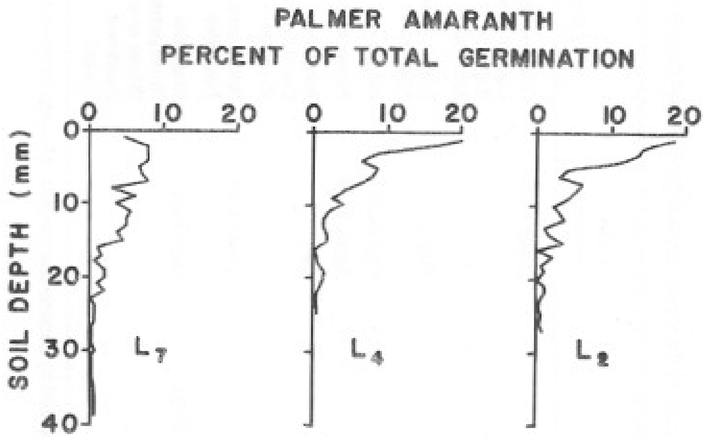

Fig. 1. Soil profile analyses of Palmer amaranth seed germination at three locations. Seeds at L_5 germinated somewhat shallower but with a pattern similar to that of L_7.

Common purslane germinated in the surface 3 mm (0.1 inch) in a sandy loam with small clods at location 1 and in the surface 9 mm (0.4 inch) in shaped beds of a clay with large clods at location 5 (Fig. 2). Horse purslane germinated in the surface 16 mm (0.6 inch) of a clay loam with large clods at location 7.

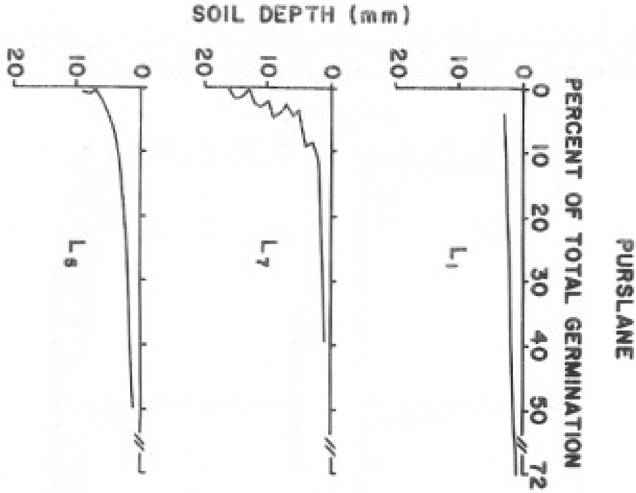

Fig. 2. Soil profile analyses of purslane seed germination at three locations. Common purslane existed at L_1 and L_5 whereas horse purslane existed at L_7.

In this study, London rocket germinated at location 1 in the surface 7 mm (0.3 inch) in flat beds of a sandy loam with small clods, but germinated in the surface 12 mm (0.5 inch) at a nearby site in 1972 (4).

Ridgeseed spurge germinated in the surface 20 mm (0.8 inch) at location 7 in shaped beds of a packed clay loam with large clods.

Ragweed parthenium germinated to a depth of 14 mm (0.6 inch) and mostly in the surface 7 mm (0.3 inch) at location 1 on a sandy loam with small clods, but germinated in the surface 26 mm (1.0 inch) of a packed clay with large clods at location 5 (Fig. 3). Anderson (1) reported germination of common ragweed (*Ambrosia artemisiifolia* L.) up to 50 mm (2.0 inches) in soils.

Wild common sunflower germinated in the surface 41 mm (1.6 inches) and mostly in the surface 10 mm (0.4 inch) at location 1 on a sandy loam with large clods, but germinated in the surface 49 mm (1.9 inches) in large clods of a packed soil at a river's edge (location 7) (Fig. 3).

Junglerice germinated in the surface 54 mm (2.2 inches) at three locations. in shaped beds of a clay with large clods at locations 2 and 5 and in a sandy loam with small clods at location 6 (Fig. 4). However, weed seeds germinated in the surface 73 mm (2.9 inches) at location 3 on a clay loam with small clods. Several researchers reported that barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) germinated up to 100 mm (4.0 inches) deep in field soils (2, 3, 5, 6).

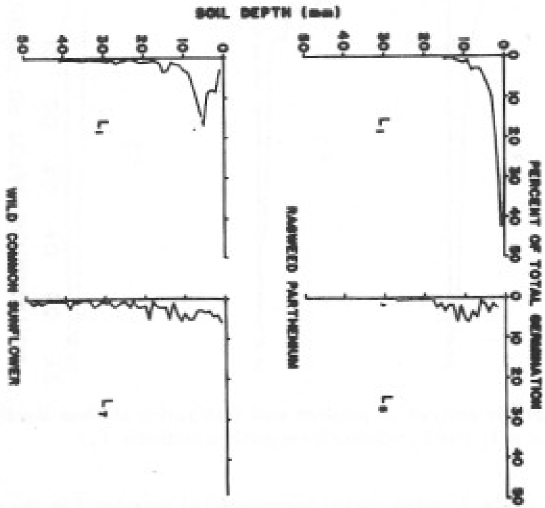

Fig. 3. Soil profile analyses of ragweed parthenium and wild common sunflower at two locations.

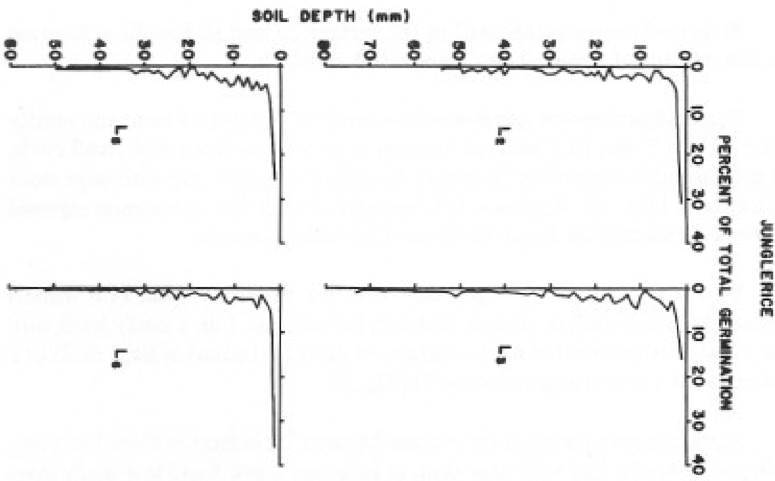

Fig. 4. Soil profile analyses of junglerice at four locations.

DISCUSSION

Dawson (3) found that the depth of germination in soil was positively correlated with seed weight of barnyardgrass. In the present study, germination as a function of soil depth was positively correlated with seed size, as shown by the germination of common purslane (0.8 mm (0.03 inch) by 0.6 mm (0.02 inch) size) in the surface 3 mm (0.1 inch) to 9 mm (0.4 inch) and the germination of common purslane (0.8 mm (0.03 inch) by 0.6 mm (0.02 inch) size) in the surface 3 mm (0.1 inch) to 9 mm (0.4 inch) and the germination of junglerice (2.2 mm (0.09 inch) by 1.2 mm (0.05 inch) size) in the surface 54 mm (2.2 inches) to 73 mm (2.9 inches) of soil.

Wiese (6) found increased germination in coarser textured soils. In the present study, apparently no correlation existed between the depth of germination and soil classification or soil surface geometry. A positive correlation existed at two locations between depth of germination of seeds and size of clods in the soil profile. These data agree with those where soil compaction increased emergence of barnyardgrass (5).

The data show that energy is wasted where herbicides are incorporated within the surface 5 to 7.5 cm (2 to 3 inches) or where ultra-high frequency (UHF) energy is applied to depths up to 12.7 cm (5 inch) in soil, where the control agents are intended for small seeds such as for the weeds Palmer amaranth, purslane, and London rocket.

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Water Stress Reduces Light Reflectance of Squash Leaves

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ABSTRACT

Mexican squash (*Cucurbita pepo* L.) plants were grown hydroponically under conditions of low (0.4 atm) and high (2.4 atm) water stress. High water stress was induced by adding an osmoticum (polyethylene glycol-1000) to the nutrient solution.

High water-stressed leaves were thicker, lower in water content, and smaller than low water-stressed leaves.

Water stress did not significantly affect spectrophotometrically measured leaf reflectance in the visible region (500 to 750 nm). In the near-infrared region (750 to 1350 nm) and in a portion of the water absorption region (1350 to 2500 nm), high water-stressed leaves had significantly lower reflectance than low water-stressed leaves.

We are frequently asked what influence water stress has on the reflectance of infrared light by plant leaves. In the field, plant water stress is induced by soil drying (matric suction) and by soluble salts in the soil (osmotic suction) (2, 12). If salt concentration is high, plant growth is affected by both water stress and toxicity caused by excessive intake of soluble salts.

Polyethylene glycol (PEG) has been used as an osmoticum (5, 6, 7, 8, 9) to impose water stress on plants by decreasing the water potential of the rooting medium and, consequently, the water potential of the plant without changing the concentration of soluble salts.

Reports of possible toxic contaminants in PEG have been published (8, 9). However, Lawlor (8) concluded that PEGs with molecular weights of 1000 or higher are not absorbed in significant quantities unless the root system is damaged. Kaufmann and Eckard (6) also reported that large PEG molecules such as PEG-6000 are more useful for simulating soil water stress than smaller molecules such as PEG-400.

In this study to determine effects of water stress on light reflectance of squash (*Cucurbita pepo* L.) leaves, water stress was induced by adding PEG-1000 to a nutrient solution.

MATERIALS AND METHODS

Mexican squash (*Cucurbita pepo* L., var. Tatume) seeds were planted in sterilized horticultural perlite contained in 4.5-liter capacity plastic pots. Seeds were watered daily with 200 ml of glass-distilled water.

Three uniform plants with macroscopically visible true leaves were transplanted into each of 14 plastic containers of 1.9-liter capacity containing continuously aerated, full strength nutrient solutions. Two treatments (low and high water stress) replicated seven times were used in a randomized complete block experimental design. Low water stress (0.4 atm) was achieved with a complete nutrient solution (Turtox's Water Culture Outfit, No. 2108171, Chicago, Illinois), and high water stress (2.4 atm) was implemented by adding polyethylene glycol-1000 (PEG-1000) to Turtox's nutrient solution. (Mention of company or trademark is included for the readers' benefit and does not constitute endorsement of a particular product listed by the U.S.D.A. over others that may be commercially available.)

A growth chamber environment was used. Range of parameters were: day temperature, 28.0 C to 29.1 C; night temperature, 20.3 C to 20.6 C; day relative humidity, 62.7 to 74.0%; night relative humidity, 88.6 to 91.1%. A 12-hr light-dark cycle was used in which light intensity approximated 800 ft-c at the top of the plants.

From the three plants (designated as A, B, and C) in each container, the first, second, and third true leaves were harvested, respectively, when leaves were large enough to cover the spectrophotometer's port. Ages at harvest for first, second, and third true leaves were 5, 6, and 8 days after leaf emergence, respectively.

Water content of leaves was determined on a dry-weight basis; leaves were oven dried at 68 C for 72 hr and cooled in a desiccator before weighing. Leaf thickness was determined with a linear displacement transducer and digital voltmeter (4). Leaf areas were measured with a planimeter.

A Beckman Model DK-2A spectrophotometer (Beckman Instruments, Inc., Fullerton, California) equipped with a reflectance attachment was used to measure total reflectance on upper surfaces of single leaves over the 500- to 2500-nm wavelength interval (WLI). The reflectance measurement on each leaf was completed within 15 min after it was harvested. Data were corrected for decay of the $BaSO_4$ standard to give absolute radio-metric data (1).

Leaf reflectance data were analyzed for variance (10). Data for first, second, and third true leaves were analyzed separately at the 550-nm (green reflectance peak), 650-nm (chlorophyll absorption band), 850-nm (on infrared reflectance plateau), 1450-nm (water absorption band), 1650-nm (reflectance peak following water absorption band at 1450 nm), 1950-nm (water absorption band), and 2200-nm (reflectance peak following water absorption band at 1950 nm) wavelengths.

RESULTS AND DISCUSSION

Plant Growth. High water-stressed squash plants were smaller than low water-stressed plants. Differences were significant (P = 0.01) between low and high water-stressed leaves in water content, thickness, and area. For the third true leaves, as an example, water content was 87.7% and 84.1%, area per leaf was 35.7 cm^2 and 4.4 cm^2, and thickness was 0.163 mm and 0.170 mm for low and high water-stressed leaves, respectively.

Transverse sections of low and high water-stressed leaves were studied with a microscope. The mesophyll of high water-stressed leaves had disorganized and distorted palisade parenchyma cells compared with the mesophyll of low water-stressed leaves.

Reflectance Spectra. Leaves were ideal for spectral measurements because they were free of disease and surface contaminents.

Fig. 1 charts the reflectance spectra of low and high water-stressed, first, second, and third true leaves of squash plants over the 500- to 2500-nm WLI. The spectral range 500- to 2500-nm WLI can be characterized by three categories (11): a) the visible region, 500- to 750-nm WLI, dominated by pigment absorption of light; b) the near-infrared region, 750- to 1350-nm WLI, a region of high reflectance affected by leaf structure; and c) the 1350- to 2500-nm WLI, a region greatly influenced by the amount of water in the leaf tissue--strong water absorption bands occur at 1450- and 1950-nm wavelengths.

Fig. 1 shows that reflectance of first, second, and third true leaves was affected the same way by water stress treatments, but only results for first and third true leaves were statistically significant (P = 0.01).

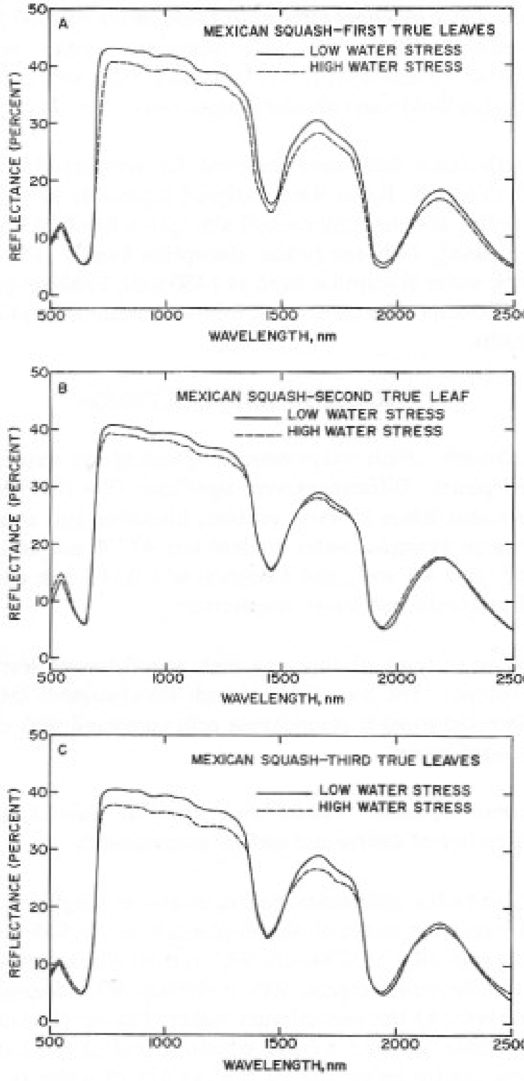

Fig. 1. Light reflectance over the 500- to 2500-nm WLI of low and high water-stressed, first (A), second (B), and third (C) true squash leaves.

Water stress treatments (Fig. 1) had no significant effect on reflectance in the visible spectral region (500 to 750 nm). However, in the 750- to 1350-nm WLI, high water-stressed leaves had significantly ($P = 0.01$) lower reflectance at the 850-nm wavelength than low water-stressed leaves. At the 850-nm wavelength, high water-stressed first and third true leaves had 2.5% and 2.9% less reflectance than low water-stressed, first and third true leaves, respectively.

In the 750- to 1350-nm WLI, light reflectance is known to be affected by internal leaf structure (3). Near-infrared light reflectance usually increases with an increase in number of intercellular air spaces because light is scattered in passing from hydrated cell walls with a refractive index of 1.4 to intercellular air with a refractive index of 1.0. For example, maturation of a cotton leaf is characterized by development of intercellular air spaces in the mesophyll; consequently, light reflectance of the leaf increases.

In this study, leaf structure also had some influence in the water absorption region (1350 to 2500 nm). The high water-stressed, first true leaves had significantly ($P = 0.01$) less reflectance than low water-stressed, first true leaves at the 1450, 1650, 1950, and 2200-nm wavelengths. The lower reflectance of high water-stressed leaves at these wavelengths cannot be attributed to water absorption because high water-stressed leaves had a lower water content than low water-stressed leaves. In addition, reflectances of low and high water-stressed, third true leaves were essentially the same at the 1450- and 1950-nm water absorption bands, whereas the reflectance of high water-stressed, third true leaves was less at the 1650-nm wavelength than low water-stressed, third true leaves.

CONCLUSION

Leaves from squash plants grown with high water stress induced with an osmoticum (PEG-1000) reflected less infrared light than leaves from squash plants grown with low water stress. Water stress reduced infrared light reflectance of plant leaves.

ACKNOWLEDGEMENT

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

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Caloric Value of Canned Conventional-Cut And French-Sliced Green Beans

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ABSTRACT

The canned conventional-cut green beans had a greater percentage of seed than did the French-sliced due to the removal of the seeds in the slicing process. Proximate analysis revealed that approximately 13% of the caloric value was lost as a result of the slicing process but that ether extract was not different for the two packs. Protein and total carbohydrates were reduced by 8 and 15%, respectively. The reduction in calories of the French-sliced could be due to the leaching of the nutrients into the cover media and to the removal of the seeds.

Nutritional value, convenience, and appearance are assuming greater roles as criteria for consumer acceptance. Most of the literature concerning green beans has dealt with varietal testing, maturity and culinary qualities; very little with nutritional value. The value of any vegetable as a food product is dependent upon its composition and palatability. Watt and Merrill (7) indicate the caloric value for canned, regular pack green beans, drained basis, to be 24 cal/100g edible portion; they make no mention of the value for French-style cut canned beans.

French-sliced green beans have gained a wide degree of acceptance (5). French-sliced green beans are prepared by slicing the bean longitudinally. During preparation a majority of the seeds are removed by the slicing and washing process leaving only the succulent pods in the canned product. This is in contrast to conventional cut green beans where a large proportion of the seeds remain in the beans and become an integral part of the canned beans. The seeds at the stage of maturity normally used in French-sliced beans may contribute significantly to the nutritive value of the canned product. Culpepper (3) has shown that the immature seeds of green beans are high in sugars and total solids and exhibit an increase after the 15-day stage of maturity. The possible lower caloric value of French-slicing of green beans may enhance their value as a diet food, and the French-sliced beans may possess certain consumer approval for selected nutritionally conscious food groups.

MATERIALS AND METHODS

The canned green beans used in the study were Blue Lake-274 cultivar and were provided form commercial packs of Renown Foods Company, McAllen, Texas. The samples were selected from comparable harvests and were subjected to harvesting, handling and processing techniques normally employed by the cannery. A combination of sieve size 4 and 5 were used in these lots and were conventionally cut and French-sliced and were canned according to standard procedures used in the cannery. Procedures of growing, harvesting, handling and canning were the same for all batches, as far as could be controlled in a commercial operation.

Twelve No. 303 cans were selected at random on two different code days with three cans from each pack being used for analysis. Drained weights and percent seed were determined according to the U. S. Standards for Grades of Canned Green Beans and Canned Wax Beans (6) with three cans of each pack being used for percent seed determinations and three cans for proximate analysis. As the cover liquor of canned green beans is not normally consumed only the drained beans were used in the analyses.

Following drained weight determinations, samples used for proximate analysis were blended in a Waring Blendor at medium speed, freeze dried, ground with a mortar and pestle, re-dried at 70 C under vacuum, and then stored until analyses were performed. (Use of a company and/or trade name does not imply endorsement by the United States Department of Agriculture over others which may also be suitable.)

Samples were taken immediately after blending for dry matter determinations which were performed according to the Official Methods of the A.O. A.C. (1).

Nitrogen was determined by the Kjeldahl method according to the Official Methods of the A.O.A.C. (1). Protein was calculated by multiplying the percent Kjeldahl N by a factor of 6.25. Ether extract and ash were determined according to the same set of procedures.

Crude fiber of fibrous material was determined according to the procedure outlined in the United States Standards for Grades of Canned Green Beans and Canned Wax Beans (6) except that the analyses were performed on the dried bean homogenates rather than on the drained beans, and results were converted to a wet weight basis.

Carbohydrate percentage was determined by adding the percent proximate analysis of the other components and subtacting from 100.

The percentages of seeds and seed pods were determined on an additional set of samples in the following manner. Three 303 cans of each pack were selected at random, opened, and drained. The drained beans were separated from the pods and all beans or parts of beans weighed. The percentage of beans and pods were calculated based on drained weight of the whole can.

RESULTS AND DISCUSSION

The difference in cutting or slicing techniques used in processing conventional-cut and French-sliced green beans results in canned beans with substantially different qualities, as shown in Fig. 1. Results were obtained for comparing the effects of type of cutting technique on drained weights, hull or pod weights and percent seed. Results from these evaluations are presented in Table 1.

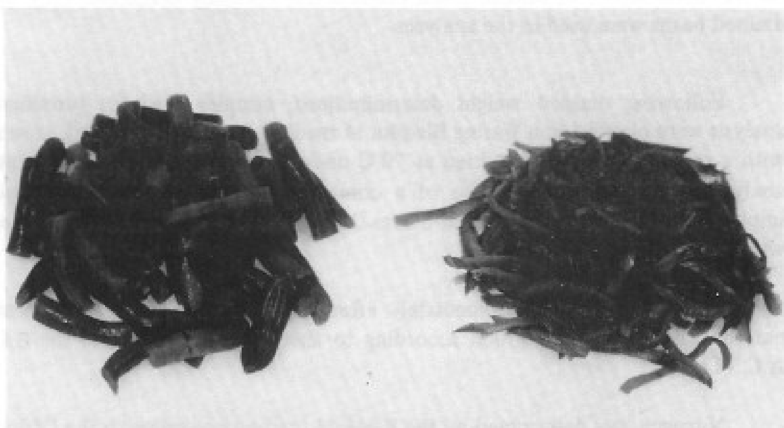

Fig. 1. A photographic representation of conventional cut (left) and French-sliced (right) green beans.

Total can contents or fill for the two packs was similar with very little difference in the drained weights. Drained weights were 280.7 g for convention-

Table 1. Drained weights, hull weights and percent seed in canned, conventional-cut and French-sliced green beans.

Type of Pack	*Can Contents*[1] *(g)*	*Drained Weight (g)*	*Hull Weight (g)*	*Seeds (%)*
Conventional Cut	473.2±2.43	280.7±1.53	258.2±0.41	7.6
French–Sliced	472.2±1.24	265.3±2.43	255.0±2.64	2.3

[1] Based on the average contents of six 303 cans, Mean ± SD

al cut and 265.3 g for the French-sliced green beans. These weights were well above the recommended minimum drained weight of 247 g for the 303 container size of canned green beans (6). The percentage of seeds was lower in the French-sliced beans (2.3%) than in the conventional cut green beans (7.6%). Most of the seed and seed particles were removed in the slicing and washing process of the French-sliced beans. The seed or seed particles, which constitute the 2.3% of the French-sliced beans, were mainly seed coats with very few particles of the seed endosperm present. These seed coat particles tended to have an appreciable amount of trapped water which caused an increase in weight that was not necessarily bean seed material. The percent seed in the conventional cut beans were at a level which reflected that the proportion of seed to pod had started to increase, and, according to Culpepper (3), an increase in total solids in the seed would follow a similar pattern.

The results from the proximate analysis of the canned conventional cut and French-sliced green beans appear in Table 2. The data presented in this table show that small differences exist in the composition of the two types of canned green beans. The moisture levels, based on drained contents of the container, were slightly higher in the French-sliced green beans, but other components, except for ether extract, were 8-15% lower. This slight difference of 1% in moisture content could be attributed to the increased surface area of the French-sliced beans which did not drain as readily in the process of sample preparation.

The crude fiber levels in beans from both packs were well under the maximum of 0.15% for standard packs as described by the United States Standards for Grades of Canned Green Beans and Canned Wax Beans (6). However, Siegel (5) has stated that it is possible to get a standard French-sliced pack with beans having a fiber content of as much as 0.20% and that this level would result in sub-standard conventionally cut packs of green beans. The levels of protein, ash and total carbohydrates were slightly lower in the canned French-sliced beans than in the canned conventional cut beans. The ether extract or lipid levels were the same in both packs and are minor components when compared with the other values. The slightly lower protein and ash values may be due to leaching of these materials into the cover liquid which was not included in the analysis. Leaching of these materials is enhanced in the French-sliced beans by their greater cut surface area. The difference in total carbohydrate levels was greater than in protein or ash values. Total carbohydrates in the French-sliced canned beans was 4.09% compared with a value of 4.82% for the conventionally cut green beans. This is probably also due to leaching of the carbohydrates into the cover media as well as from the loss of the seeds in the slicing process. Culpepper (3) has shown that the immature seeds of green beans have high levels of soluble carbohydrates.

Table 2. Proximate analysis of canned conventional-cut and French-sliced green beans.

Component	*Conventional Cut*	*French-Sliced*
	%	
Moisture	92.60	93.60
Ash	1.27	1.10
Fiber	0.07	0.06
Protein	1.12	1.03
Ether Extract	0.12	0.12
Carbohydrate	4.82	4.09

The caloric value of foods is dependent upon the types of organic matter undergoing oxidation and may be estimated from the percentage composition as determined by proximate chemical analysis. The conversion from proximate analysis values to caloric value is accomplished by multiplying the percentage of protein, ether extract or fat, and carbohydrates by the factors of 4, 9, and 4, respectively (4). The calculations of caloric values for canned conventional cut and French-sliced green beans are presented in Table 3. The caloric values calculated on canned conventional cut and French-sliced green beans were 24.8 and 21.6 cal/100 g, respectively. These values are compared with 24 cal/100g as reported by Watt and Merrill (7) for conventional cut and 21.8 cal/100 g as reported by Chatfield and Adams (2) for French-sliced when caloric values were recalculated by using the above factors. As caloric values are based on protein, lipid, and carbohydrate percentages, the slight reduction noted in caloric value of the French-sliced green beans was due to the decrease in the protein and carbohydrate content since lipid levels were not different. The caloric value for carbohydrate was 15% less for French-sliced beans, and was 8% less for protein; the overall reduction of caloric value was 13%. Converting the caloric value to values for total can contents, drained weight basis, it was found that a loss of 12.6 cal/303 can of canned green beans resulted from French-slicing. As low caloric value is part of the appeal of green beans to dietitians and weight watchers, even the slight reduction from French-slicing will be of interest tc these groups.

Table 3. Caloric value of canned conventional and French-sliced green beans.

Component	*Conventional Cut* (Cal/100g)	*French-Sliced* (Cal/100g)
Protein x 4.	4.48	4.12
Ether Extract x 9	1.08	1.08
Carbohydrate x 4	19.28	16.36
Total	24.84	21.58

ACKNOWLEDGEMENT

The participation of Mr. L. W. Fritz of Renown Foods Company, McAllen, Texas in providing the green bean samples, and the growing, handling and processing information is gratefully acknowledged.

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The Quality of Freeze-Dried and Compressed Green Beans and Carrots

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ABSTRACT

Seven green bean and 20 carrot cultivars were evaluated to determine which chemical and physical attributes of the fresh vegetables are useful in predicting quality of the freeze-dried, compressed and rehydrated product. Superior cultivars for this process were also determined. For fresh green beans it was found that dry matter, fiber, water soluble pectin, calgon soluble pectin, hemicellulose and Gardner color values are useful in predicting processed quality. Gardner color values were sufficient to predict quality for carrots.

Compression of freeze-dried material has warranted attention as a means of reducing bulk volume (3, 7, 8, 13, 14). In order to achieve high quality finished products, the *a priori* requirement of high quality raw materials cannot be overemphasized (11). The Aberdeen Group of the Ministry of Foods (9) gave special consideration to raw materials for freeze-drying and presented data on the quality of 27 different items.

It is logical to expect that varietal differences are related to the compression technology of freeze-dried vegetables. The purpose of this study was to objectively describe those chemical and physical attributes of fresh green beans and carrots which directly affect the quality of the freeze-dried, compressed and rehydrated product. This study was further designed to delineate superior green bean and carrot cultivars for freeze-drying and compression.

MATERIALS AND METHODS

Green beans. Green beans of seven cultivars (Table 1) were selected from varietal studies on the Texas A&M Horticultural Farm. They were washed and cut into 1-inch lengths immediately after harvest. Samples for fresh analysis were randomly drawn at this point. Green beans for subsequent freeze-drying and compression were then given an extended blanch for 5 min at 212 F, chilled in ice water, and frozen in liquid nitrogen for approximately 20 sec. The product was freeze-dried to 2% moisture in a REPP Model FDD-15 Sublimator at a shelf temperature of 100 F for 48 hr. Samples of 10 g each were plasticized by spraying with distilled water to 15% moisture and compressed into 2¼-inch diameter discs with a Carver Laboratory Press at 2,000 psi and 30 sec dwell time. The discs were then frozen and freeze-dried to a final 2% moisture. Subsequent rehydration was accomplished by floating the compressed product in 150 F water for 20 min and then draining for 5 min prior to sensory evaluation.

Carrots. Carrots from twenty cultivars (Table 2) were obtained from the 1972 carrot trials of the Texas Agricultural Experiment Station and the Texas Agricultural Extension Service. The carrots were grown at Hondo, Texas and transported to the University in perforated plastic bags. Upon arrival they were washed and stored at 34 F until processed. The carrots were peeled using 10% lye solution for 1 min at 190 F. They were steamed for 4 min and immediately run twice through a rod washer. The carrots were hand trimmed and sliced into 3/16-inch slices. Samples for fresh analysis were randomly drawn at this point. The slices were blanched for 5 min at 212 F, chilled in ice water and 100-g samples drawn for shear determinations. Slices for freeze-drying were frozen in liquid nitrogen and freeze-dried to 2% moisture with a shelf temperature of 100 F for 48 hr. Ten-gram samples of dehydrated carrots were sprayed with distilled water to 15% moisture and compressed into 3 x 1 x ½ inch bars with a Carver Laboratory Press using 1,000 psi with a dwell time of 30 sec. The bars were frozen and freeze-dried to 2% final moisture. Rehydration was accomplished by floating the carrot bars in 150 F water for 1 hr. The dehydrated carrots were drained for 5 min prior to sensory evaluation.

Objective Evaluation. The percent dry matter was determined according to the procedures of Hall and Hacskaylo (6).

An Allo-Kramer Shear Press equipped with a recorder was used to objectively measure the texture of the two vegetables. A 50-g sample of deseeded green beans was placed so that the pods were diagonal to the slots of the shear cell. For the sliced carrots, a 100-g sample was placed randomly in the shear cell. The 13-bladed multi-purpose shear was used with a 300 lb test ring with a down stroke time of 30 sec. The recorder was set on the 3,000 sensitivity setting. The maximum height of the shear peak was thus observed.

Table 1. Ranking of cultivar means for fresh green bean attributes and acceptance of freeze-dried, compressed and rehydrated green beans.

ATTRIBUTE	CULTIVAR						
	XIDA 68-1229	*XIDA 68-2988*	*Eagle*	*Astro*	*Avalanche*	*Pirol*	*Falcon*
FRESH							
Dry Matter[b]	1	2	3	5	4	7	6
Fiber[b]	3	2	1	7	4	5	6
Water Soluble Pectin[c]	1	2	3	5	4	7	6
Calgon Soluble Pectin[c]	2	3	1	4	5	6	7
Hemicellulose[b]	1	2	3	5	6	4	7
Gardner Color Values							
"L"[b]	3	1	2	4	6	7	5
"a"[b]	1	3	2	5	6	4	7
"a/b"[c]	1	3	2	5	6	4	7
PROCESSED							
Taste Panel Acceptance	1	2	3	4	6	6	7
Rank No. Totals	14**	20*	20*	44	46	50	58*
Rank of Totals	1	2	3	4	5	6	7
Range of Totals	2	2	2	3	2	3	2

[a]Range, 1-7 from most to least desirable
[b]Based on negative correlation coefficients with acceptance
[c]Based on positive correlation coefficients with acceptance
*Significant at the 5% level
**Significant at the 1% level

Table 2. Ranking of cultivar means for fresh carrot attributes and acceptance of freeze-dried, compressed and rehydrated carrots.

CULTIVARS	FRESH Gardner Color Values "L"[b]	"a"[c]	"b"[b]	"a/b"[c]	PROCESSED Taste Panel Acceptance	Rank No. Total	Rank of Totals	Range of Totals
	Ranking of Attributes[a]							
Hybrid 13C-X15	1	1	1	1	3	7**	1	2
Spartan Bonus	4	3	7	4	1	15**	2	6
Hybrid 13C-X19	2	5	2	2	4	15*	3	3
Expt. Hybrid	3	6	3	5	5	16*	4	3
Spartan Fancy	6	2	6	3	13	30	5	11
Spartan Delite	7	4	11	6	8	36	6	7
Spartan Sweet	8	9	5	7	10	39	7	5
Ace	5	7	11	8	9	40	8	6
Danvers Pride	12	11	9	11	2	45	9	10
XP-115	11	10	13	10	6	50	10	7
Hybrid 9W98	10	12	8	12	12	54	11	4
Imperator 408	14	8	15	9	14	60	12	7
XP-127	9	19	4	13	17	62	13	15
King Imperator	15	15	11	15	7	63	14	8
Grenadier	13	13	14	14	11	65	15	3
XP-108	20	18	18	18	20	84	16	2
Hybrid 9W156	18	18	17	18	16	87	17	2
Imperator 58	16	20	16	20	15	87	18	5
Gold Pak 28	19	18	19	18	19	93**	19	1
Danvers 126	17	14	20	16	18	95**	20	6

[a]Range, 1-7 from most to least desirable
[b]Based on negative correlation coefficients with acceptance
[c]Based on positive correlation coefficients with acceptance
*Significant at the 5% level
**Significant at the 1% level

The percent fiber of green beans was measured by the FDA method (12). The carrot fiber was considered to be of minimal importance and was not determined.

The Gardner Automatic Color Difference Meter was utilized to determine the color of a 1:1 blend of product and water (2).

The carbohydrates were extracted using the procedures of Sistrunk (16). The phenol-sulfuric acid method (5) was utilized to determine the starch, total sugar, hemicellulose and cellulose content. Water-soluble and calgon-soluble pectin was determined colorimetrically (4).

Subjective Evaluation. Sensory evaluation was performed by a trained sensory panel composed of seven members. A nine-point hedonic rating scale was used for scoring appearance, color, flavor, texture and overall acceptance.

Statistical Design. The statistical relationship of the chemical, physical and sensory attributes was established by means of analysis of variance and correlation coefficients. Significance of differences for ranked data (10), was used to determine superior green bean and carrot cultivars.

RESULTS AND DISCUSSION

The fresh attributes for green beans which were found to be correlated (P less than 0.01) with overall acceptance of the sensory evaluation are presented in Table 3. Of the fresh green bean attributes measured, dry matter, fiber and Gardner Color values are of the greatest interest because of the speed and simplicity of performing these analyses. The carbohydrate analyses require much time and effort. Ranking of the data for all attributes and acceptance

Table 3. Correlation coefficients of fresh quality attributes with acceptance of freeze-dried, compressed and rehydrated green beans.

Attribute	*Correlation*	%
Dry Matter	-0.75**	10.7
Fiber	-0.67**	0.037
Water Soluble Pectin	0.75**	0.840
Calgon Soluble Pectin	0.67**	2.24
Hemicellulose	-0.75**	7.27
Gardner Color		Value
"L"	-0.74**	52.0
"a"	-0.76**	18.0
"a/b"	0.75**	1.11

**Significant at the 1% level.

for all cultivars indicated breeding line XIDA 68-1229 was the superior green bean cultivar (Table 1). Green beans possessing attributes as those presented in Table 3 can be expected to yield an acceptable freeze-dried, compressed and rehydrated bean.

For fresh carrots, significant correlation coefficients (P less than 0.01) were obtained only between Gardner color values and acceptance scores of the freeze-dried, compressed and rehydrated vegetable (Table 4).

Table 4. Correlation coefficients of fresh carrot color with acceptance and desirable fresh color attributes for freeze-dried, compressed and rehydrated carrots.

Gardner Color	*Correlation*	*Value*
"L"	-0.65**	40.4
"a"	0.46**	22.9
"b"	-0.60**	20.7
"a/b"	0.56**	1.11

**Significant at the 0.01% level

Carrots possessing desirable Gardner color values (Table 4) can be expected to yield an acceptable freeze-dried, compressed and rehydrated carrot. The Gardner color "a/b" ratio is perhaps the best indicator of desirable fresh carrot color, which agrees with Shallenberger and Wallace (15) and Bradley and Rhodes (1). Ranking of the data for the 20 carrot cultivars tested indicated that the most outstanding cultivar was the Ferry-Morse Hybrid 13C-X15 (Table 2).

ACKNOWLEDGEMENTS

This study was supported by the National Aeronautics and Space Administration, Contract No. NAS9-12434 administered by the Johnson Space Center, Houston, Texas.

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Effect of Preservatives on Refrigerated Storage of Liquid-Nitrogen-Peeled Fresh Tomatoes

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ABSTRACT

Chico III and Super Market tomato cultivars were peeled with liquid nitrogen or hot water, treated with preservatives, packaged in polyethylene bags and stored at 40 F. After 9 days storage nitrogen-peeled tomatoes which had been dipped in 0.1% sorbic acid were considered by a taste panel to have acceptable flavor. Small differences in titratable acidity, pH, and color could not be attributed to peeling methods or chemical treatments other than the difference caused by treating Super Market with SO_2. Super Market treated with SO_2 had a sour smell after 4 days of storage regardless of the peeling method used.

Liquid nitrogen-peeled fresh tomatoes could be a new convenience item that would be suitable for distribution to institutional and possibly to retail trade if the tomatoes could be packaged and stored under refrigeration for a suitable length of time. El Monte variety tomatoes peeled with liquid nitrogen, sealed in polyethylene bags, and refrigerated remain edible for 5 days and possibly longer (9). The tomatoes were not treated with a preservative.

Several investigators have reported that pre-peeled fruit or vegetables would have longer shelf life if treated with a preservative. Francis (3) found that peeled carrots dipped 5 min in 0.2% sorbic acid and 0.1% Tween-20 in 2% orthophosphoric acid and packed in polyethylene bags kept 4 to 5 days at room temperature or up to 3 weeks when refrigerated. Bolin et al. (1) dipped pre-peeled apple wedges in 0.25% $NaHSO_3$ for 45 sec and then in 0.2% K_2HPO_4 (pH 8.8) for 5 min and reported that the combination of SO_2 and buffer treatment maintained a light colored crisp wedge for 3 weeks in cold storage. Francis and Jimenez (4) reported that the shelf life of pre-peeled cubed squash could be extended 1.5 to 2 times by dipping the squash into 0.2% sodium dehydroacetate. Shapiro and Holder (7) found that oxytetracycline and Biostate, (Chas. Pfizer & Co., Inc.), at pH 5.0 effectively decreased the microbial population of fresh vegetables or maintained low counts for 1 week. (Reference to a company or product name does not imply approval or recommendation of the product by the U.S.D.A. to the exclusion of others that may be suitable.)

This investigation was undertaken in an attempt to increase the refrigerated storage time of pre-peeled tomatoes by treating them with sorbic acid, sodium benzoate or sodium metabisulfite.

MATERIALS AND METHODS

Super Market, a round, fresh market-type tomato and Chico III, a pear-shaped canning-type tomato were used for this study. About 750 lb of red-ripe uniform size Super Market tomatoes were harvested and divided into three equal groups in order to compare the preservative treatments on unpeeled, liquid nitrogen-peeled, and hot water-peeled tomatoes. Tomatoes in the second group were submerged 20 sec in liquid nitrogen, thawed 30 sec in 90 F water, and the skin sack slipped from the tomatoes (2). Fruit in the third group were submerged 60 sec in boiling water, cooled in tap water, and peeled by hand. Each group of tomatoes was separated into four lots for treatment. The first lot was untreated, the second lot was dipped in 0.1% sorbic acid, the third lot in 0.1% sodium benzoate, and the fourth lot in 1% SO_2. All lots were dipped for 30 sec. The tomatoes were drained and packaged eight to each polyethylene bag, sealed, and stored at 40 F.

After completing the storage tests on Super Market, about 600 lb of Chico III were obtained from a local canning plant and the procedure repeated using this cultivar. The SO_2 treatment was eliminated since it caused Super Market tomatoes to discolor and develop an off-flavor. After the tomatoes were treated they were packaged in polyethylene bags, 15 per bag, sealed, and stored at 40 F.

Daily except on weekends, two bags from each treatment were examined for exudative loss, titratable acidity, pH, Brix, color, and evaluated for taste. Before examination, the control sample of unpeeled tomatoes was hand-peeled. One-half of each tomato was used for analysis and the other half for the taste evaluation. Each bag of tomatoes was analyzed independently, except that for the sensory evaluations tomato halves from both bags were combined for a larger sample.

Exudative loss was determined by cutting a hole in the bottom of the polyethylene bag and allowing the tomatoes to drain for 5 min. The bag and tomatoes were supported in a 4-inch funnel. Total titratable acidity was determined by titrating with standardized NaOH, Brix was measured on a Bausch and Lomb Refractometer, pH was measured by a Corning Model 10 pH meter, and color was determined with a Gardner Color Difference meter standardized with a tomato red color plate, Rd 5.36, a 30.4 and b 14.6.

Sensory evaluation was made by seven judges, according to the hedonic-scale method of Peryam and Pilgram (5). Tomato halves were cut into bite-size slices and at least five slices from different tomatoes were presented, unsalted, to each judge in an effort to reduce variability caused by differences in maturity. Each judge was asked to rate the tomato slices according to flavor. Taste evaluation was discontinued when the bags of tomatoes developed a soured smell.

RESULTS AND DISCUSSION

Exudation was, in general, greater from hot water-peeled than from nitrogen-peeled tomatoes regardless of preservative treatment (Table 1). Exudation from nitrogen-peeled Super Market tomatoes treated with SO_2 was an exception; it was not significantly greater than untreated water-peeled or water-peeled tomatoes treated with sorbic acid. Hot water peeling softened the tomatoes and seemed to cause cell breakdown and allow the watery phase to exude from the tomatoes. Exudation from Super Market peeled with nitrogen and treated with sodium metabisulfite was significantly greater than from untreated tomatoes or tomatoes treated with sorbic acid, but was not significantly greater than from tomatoes treated with sodium benzoate. The action of the SO_2 seemed to affect the cells of the tomatoes causing the watery phase to be exuded during storage. Exudation from nitrogen-peeled Chico III tomatoes was a little greater than from nitrogen-peeled Super Market and the loss from water-peeled, untreated Chico III was greater than the loss from Super Market. This difference in exudation was unexpected because Chico III is considered to be firmer than Super Market. The greater exudative loss from Chico III could have been caused by harvesting and handling methods. Chico III was moved from the field to the canning plant in large bulk bins, from which the tomatoes were selected and taken to the laboratory. Super Market was harvested by laboratory personnel and moved to the laboratory in small field boxes.

There were small statistical differences in the titratable acidity, pH, and color notations of Super Market and small differences in pH of Chico III, but the differences could not be attributed to peeling methods or to chemical treatments other than the differences caused by treating peeled Super Market tomatoes with SO_2. These differences were: a slight increase in titratable acidity, a decrease in pH, and fading of color from red to yellow-red after 3 days of storage (Table 1). Fruits of Chico III from all treatments had a large a/b ratio, which indicates a redder color, than those of Super Market. The Brix readings of 4.5 to 5.1 for Super Market and 4.3 to 4.6 for Chico III were not significantly different and are not reported.

Table 1. Evaluation of unpeeled, nitrogen-peeled, and water-peeled tomatoes treated with preservatives.

Peeling Method	*Treatment*	*Exudation %*	*Titratable acidity %*	*pH*	*Color notation a/b*
		SUPER MARKET			
Unpeeled	None	–	0.46a[1]	4.33bcd[1]	1.90bc[1]
	Sorbic acid	–	0.49ab	4.36bcd	1.89bc
	Sodium benzoate	–	0.49ab	4.39d	1.93c
	SO_2	–	0.50b	4.37cd	1.88bc
Nitrogen-peeled	None	2.9a	0.51bc	4.36bcd	1.89bc
	Sorbic acid	1.4a	0.50b	4.34bcd	1.87bc
	Sodium benzoate	1.5a	0.51bc	4.34bcd	1.84bc
	SO_2	7.4b	0.57d	4.22a	1.70a
Water-peeled	None	6.6b	0.54cd	4.32bc	1.87bc
	Sorbic acid	6.7b	0.55d	4.30b	1.84bc
	Sodium benzoate	7.7c	0.54cd	4.31bc	1.83b
	SO_2	9.5c	0.56d	4.22a	1.72a
		CHICO III			
Unpeeled	None	–	0.37a	4.46ab	2.41a
	Sorbic acid	–	0.38a	4.47b	2.48a
	Sodium benzoate	–	0.37a	4.48b	2.46a
Nitrogen-peeled	None	3.1a	0.39a	4.45ab	2.48a
	Sorbic acid	3.1a	0.38a	4.41a	2.43a
	Sodium benzoate	2.7a	0.36a	4.46ab	2.42a
Water-peeled	None	9.2c	0.41a	4.45ab	2.46a
	Sorbic acid	6.3b	0.38a	4.48b	2.46a
	Sodium benzoate	5.6b	0.33a	4.43ab	2.41a

[1] Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (8).

Sensory evaluation was the most useful criterion in determining the storage life of the tomatoes. A sour smell, characteristic of tomatoes, was detected in the bags before a change in titratable acidity, pH, Brix, or color was noted.

The flavor of nitrogen-peeled tomatoes of Super Market and Chico III treated with sorbic acid was acceptable after 9 days at 40 F (Table 2). The sensory score for Super Market changed from 7.3 on the first day to 4.4 on the ninth day, and Chico III changed from 6.9 to 4.6; final scores were low but the judges considered the flavors to be acceptable. All of the tomatoes, fresh or treated, were scored low, possibly because they were unsalted. Salted and unsalted fresh-peeled tomatoes were presented to the same taste panel and the following scores were obtained: $7.8 \pm .97$ and $5.6 \pm .92$ (mean and standard deviation of three evaluations by eight judges). These results suggest the final scores of 4.4 and 4.6 might have been greater if the tomatoes had been salted. A perfect score of 9 is possible using the sensory evaluation method of Peryam and Pilgrim (5). Stephens et al. (9) reported low scores for El Monte and concluded that a lack of salt might be a factor. However, salt was not used because it might have altered or masked the flavor of the tomatoes.

The flavor of unpeeled tomatoes, regardless of the treatment, was acceptable after 9 days of storage. One bag of unpeeled Super Market treated with sodium benzoate developed a sour smell and the sensory evaluation was terminated on that sample. It is difficult to explain why one bag of unpeeled tomatoes would develop a sour smell after only 9 days of storage at 40 F. Generally refrigerated ripe tomatoes will remain in good condition longer than 9 days. whether they have been dipped in a preservative or not. Scott and Hawes (6) reported no evidence of breakdown or decay of ripe tomatoes stored for 17 days at 50 F.

Before the end of the ninth day tomatoes peeled with hot water developed a sour smell regardless of treatment. Water-peeled Chico III tomatoes treated with sodium benzoate remained acceptable for 8 days, but were soft. Stephens et al. (9) reported that hot water-peeled El Monte tomatoes without a preservative treatment, had not spoiled after 11 days and indicated the boiling water treatment might have retarded the organisms causing the sour smell. Hot water-peeling did not have the same effect on Super Market or Chico III.

Liquid nitrogen-peeled tomatoes treated with sorbic acid remained edible longer than peeled tomatoes which had not been treated with a preservative.

Results indicated that variety and handling after harvest influenced shelf life and acceptability of pre-peeled tomatoes.

Table 2. Sensory evaluation of tomatoes treated with preservatives.[1]

Peeling method	Treatment	1	2	3	4	6	7	8	9
		SUPER MARKET — *Days in storage*							
Unpeeled	None	7.4	6.7	6.6	7.1		6.9	6.4	6.4
	Sorbic acid	6.9	6.9	7.0	6.3		6.0	5.7	5.0
	Sodium benzoate	7.4	7.0	6.6	6.7		6.7	5.1	S[2]
	SO_2	7.3	6.7	6.6	5.9		5.9	5.1	5.0
Nitrogen-peeled	None	7.3	7.3	5.0	5.0		S	–	–
	Sorbic acid	7.3	6.4	5.4	5.9		5.0	4.4	4.4
	Sodium benzoate	6.7	7.1	7.0	6.1		4.6	S	–
	SO_2	4.9	4.3	4.3	S		–	–	–
Water-peeled	None	6.6	6.0	6.1	6.3		S	–	–
	Sorbic acid	5.1	6.3	5.1	4.4		S	–	–
	Sodium benzoate	4.9	6.3	5.3	4.0		S	–	–
	SO_2	5.1	4.4	3.6	S		–	–	–
		CHICO III							
Unpeeled	None	7.1		6.0		7.7	6.9	7.3	6.9
	Sorbic acid	7.3		6.6		7.3	6.9	6.6	7.0
	Sodium benzoate	7.1		5.7		6.9	6.1	7.4	7.6
Nitrogen-peeled	None	6.9		5.7		6.9	5.6	5.3	S
	Sorbic acid	6.9		6.1		6.1	6.0	6.4	4.6
	Sodium benzoate	6.0		6.0		6.3	4.7	4.7	S
Water-peeled	None	5.0		5.6		S	–	–	–
	Sorbic acid	2.7		5.9		S	–	–	–
	Sodium benzoate	5.0		6.1		6.0	4.4	4.0	S

[1] Numerical values represent the mean of three evaluations by seven judges using a nine point scale where 9 = "like extremely" and 1 = "dislike extremely".

[2] Tomatoes developed a sour smell.

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Mapping Cold-Night Surface Temperatures of the Lower Rio Grande Valley

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ABSTRACT

First attempts at representing surface temperatures of extensive land and water areas on a night of impending freeze using high resolution satellite data are briefly described. The results are encouraging and suggest that practical operational uses will likely be made of thermograms from a new generation of satellites.

A new generation of earth-orbiting satellites equipped with high resolution thermal scanners is greatly increasing the practicality of obtaining land-surface temperature data over large areas. Possible uses for surface temperature information include: aiding in the prediction of location and duration of freeze conditions; identifying the severity and geographic pattern of freeze damage; delineating warm land areas with low freeze hazard; determining when soil temperature is suitable for planting; showing the areal extent of thunderstorms from their effect on soil temperatures; locating thermal pollution of water bodies; estimating evaporation from lakes; assessing the meteorological energy balance over large areas; and aiding in operational decisions concerned with farm and range management. Wiegand (5) has given more detailed discussion of such application.

SATELLITE USED TO MEASURE TEMPERATURE

The purpose of this paper is to discuss nighttime surface temperature data obtained with the NOAA-2 satellite, an operational meteorological satellite monitored by the National Oceanic and Atmospheric Administration (4).

The NOAA-2 satellite has global coverage of the earth twice daily, crossing the equator in polar orbit at 0900 local sun time southbound and at 2100 northbound. It orbits at about 1450 km above the earth and scans a 3700-km-wide swath beneath its path.

NOAA-2 depends entirely on scanning radiometers for imagery. Its operational Scanning Radiometer has a resolution of 4.0 km in the visible spectrum and 7.5 km in the thermal infrared. Also on board NOAA-2 is a research oriented 2-channel Very High Resolution Radiometer (VHRR) with a resolution of 0.9 km in both channels. It is sensitive to wave-length intervals from 0.6 to 0.7 um in the visible and 10.5 to 12.5 um in the infrared. The VHRR infrared detector is the sensor of interest in our examination of cold -night temperatures.

CALIBRATION OF SATELLITE

On the freeze-night of 20 December 1973 efforts were made to verify the Lower Rio Grande Valley surface temperatures indicated by NOAA-2. Because of varying atmospheric attenuation, corrections are required for even the most perfectly calibrated satellite sensors.

To obtain calibration data, an airplane fitted with a precision radiation thermometer (PRT) and a fast-response strip chart recorder was flown over the Valley on that cold night at 300 m above the land surface. Following a 530 km course (Fig. 1), it started 45 min before the time of the satellite overpass. In a previous esperiment this airborne surface-temperature measuring instrumentation had demonstrated its suitability in obtaining cold-night surface temperature transects (2). Especially important in the calibration were PRT temperature determinations of Falcon Reservoir.

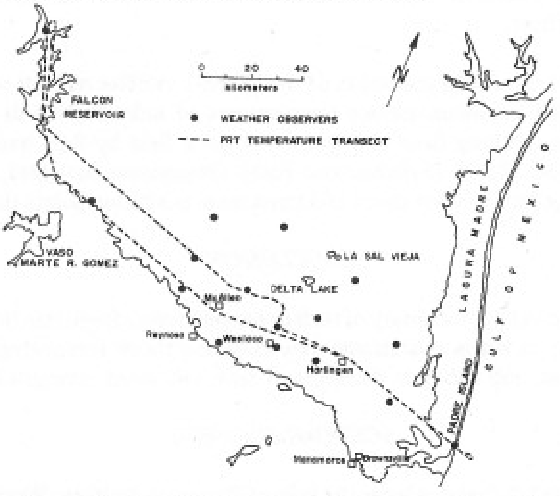

Fig. 1. The Lower Rio Grande Valley area of interest on nights of impending freeze.

During the same night, detailed radiation, surface temperature and meteorological data were collected at a highly instrumented bare soil site at the Soil and Water Conservation Districts' Research Farm, Weslaco. These measurements made in the Lower Rio Grande Valley and the National Weather Service upper air observations were used to adjust the satellite data in this first known application of VHRR data to surface mapping of a freeze event.

FUTURE APPLICATIONS

Fig. 2 and 3 illustrate developments in calibrating and displaying NOAA-2 thermal data. These examples indicate that progress will be made in applying satellite data to meet the needs mentioned earlier. However, NOAA-2 (and recently NOAA-3) data are available for only two times per day. In matters related to freeze conditions it would be desirable to have temperature information more frequently throughout the day and night.

A satellite that will meet this frequency requirement is GOES-1 (Geostationary Operational Environmental Satellite) scheduled for launch in 1974. Its synchronous orbit above the western hemisphere will permit scanning in the visible and thermal infrared spectral regions every 30 min. Such data could find application in forecasting minimum temperature and revising temperature forecasts associated with freeze events. Preparations are already underway for essentially real-time transmission of the infrared images from GOES-1 to satellite field services stations at strategic locations around the country (1). From those locations the information will be routed to Weather Service Forecast Offices.

The 8-km infrared resolution of the GOES-1 satellite will not relate closely enough to the minimum surface temperatures of individual fields to estimate crop damage resulting from a freeze event on a field by field basis. Another similar satellite, SEOS (Synchronous Earth Observation Satellite), now in the planning stage, will provide about 100 times more resolution points than GOES-1.

CONCLUSION

The increasing availability of surface temperature information from satellites will probably result in operational uses including freeze forecasting, estimating freeze damage, and aiding in decisions of farm and range management.

ACKNOWLEDGMENT

We gratefully acknowledge the help of Raymond Smithey, Wayne Swanson,

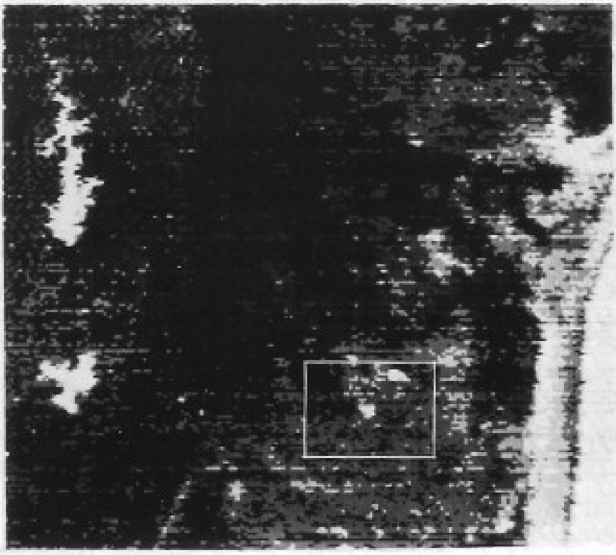

Fig. 2. Gray-scale surface temperature representation of the Lower Rio Grande Valley at 2107 CST, 20 December 1973. Warmest areas appear light and coldest areas are dark.

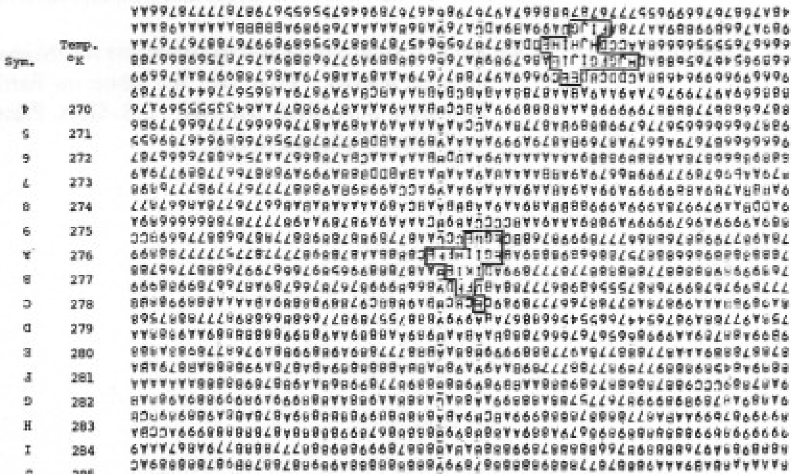

Fig. 3. Example of computer line-printer representation of nighttime surface temperatures. Each symbol represents a 1.0 K temperature range and each printed point represents an area of 0.8 km^2.

Ron Bowen, Ned Lynn, and Roger Moore in obtaining satellite calibration data. We also appreciate the cooperation of the 16 weather observers who gratuitously made air temperature measurements in relation to the satellite overpass on 20 December 1973.

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Air, Soil, and Tree Tissue Temperatures in an 8-Year Old Grapefruit Grove During the December 20, 1973, Freeze

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ABSTRACT

Air temperatures at 5, 20, and 40 ft and soil temperatures at 6-and 12-inch depths in the center of a 7-acre grapefruit grove near Weslaco, TX, are given for a freeze night on 20-21 December 1973. Leaf, limb, trunk, and fruit temperatures of 8-year-old grapefruit trees were also recorded. Air temperature at the 5-ft level remained below 32 F for 11 hr and below 25 F for 7.5 hr. The 21 F minimum was reached at 4 AM. An inversion developed during the early part of the night (5 F warmer at 40 ft than at 5 ft), but the temperature difference became less pronounced during the early morning. Soil temperature decreased 11 F during the night at the 6-inch level and 5 F at the 12-inch level. Leaf temperature was closely related to air temperature, and exposed leaves reached a minimum temperature of 20.5 F and were killed. Trunk temperature never fell below the freezing point. Fruit temperature reached a minimum of 25.5 F at 2:30 AM. The temperature rose slightly after the minimum, indicating ice formation. Observation of ruptured juice sacs after the freeze indicated that ice formed, but fruit damage was not serious.

Freezes are the main hazard to growing citrus in the Lower Rio Grande Valley. Temperatures during three major freezes in the last 25 years (1949, 1951, and 1962) have been described (2). The effects of the December 1973 freeze were not nearly as serious as those in 1962, but trees were extensively defoliated and fruit was damaged, particularly oranges, in the interior sections of the growing area. The freeze on the night of 20 December 1973, was of the radiation type, with clear skies and very little air movement. It would be classified a "frost" in Turrell's terminology (3). The degree of damage depended on air drainage, soil conditions, and age of the trees. Many young trees were killed, especially in low areas. This report describes conditions in the center of a 7-acre citrus grove at the USDA Research Farm, 5 miles north of Weslaco, during the night of 20-21 December 1973.

MATERIALS AND METHODS

The temperature was measured at a recording station set up in the center of an 8-year-old grapefruit (*Citrus paradisi* Macf.) grove. The trees were planted at 15 x 25-ft spacing. The rootstock was sour orange, *C. aurantium* L., and the grove was mechanically cultivated. A 24-point Honeywell Electronic 15 recorder was used (mention of a trade name, a proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may be suitable). The recorder printed the temperatures measured by 24-gauge copper-constantan thermocouples on a strip chart every 6 min from 5 PM on 20 December to 9 AM on 21 December 1973. Air temperature was measured with sheltered thermocouples at the 5-ft level inside and outside the trees canopy and 20 and 40 ft above the ground on a metal tower. Soil temperature was measured by thermocouples buried 6 and 12 inches deep. On each of two trees, thermocouples were inserted into the center of one fruit on the north and the south sides of the canopies to monitor the temperature of the fruit. Leaf temperatures were measured by thermocouples fastened to exposed leaves and leaves inside the canopies on the north and south sides of each tree. One thermocouple was inserted under the bark of the trunk 12 inches above ground on each tree. Limbs 2 inches thick and 4 ft above the ground were monitored the same way. Damage to the trees was assessed 2 weeks after the freeze.

RESULTS AND DISCUSSION

Air temperatures (Fig. 1) dropped about 11 F between 5 and 7 PM. Between 7 and 8 PM, there was a plateau with a decrease of only 1 F or less. After 8 PM, however, temperatures continued to fall rapidly until about 1:30 AM. At the 5-ft level, 32 F was reached before 9 PM, and at 1:30 AM, the temperature was 22 F. The minimum of 21 F was reached at 4 AM.

A temperature inversion developed at the 40-ft level after 9 PM. The temperature difference between 40 ft and 5 ft reached a maximum of 5 F at 1 AM and remained stable for 3 hr but then decreased to 2 F at 6 AM. At the 20-ft level, the temperature was about 2 F warmer than at 5 ft, a difference about half that between 5 and 40-ft levels above the ground. Throughout the night, the air inside the tree canopies was only 1 to 2 F warmer than air in the open area between the rows. At both places, the temperature remained below the freezing point for 11 hr and below the 25 F mark from midnight to 7:30 AM.

Soil temperature at the 6-inch depth declined steadily from 60 F at 5 PM to 49 F at 9 AM. At the 12-inch depth, the soil temperature rose 1 F between 5 and 8 PM, but then slowly decreased to 56 F at 9 AM, 5 F lower than at 8 PM.

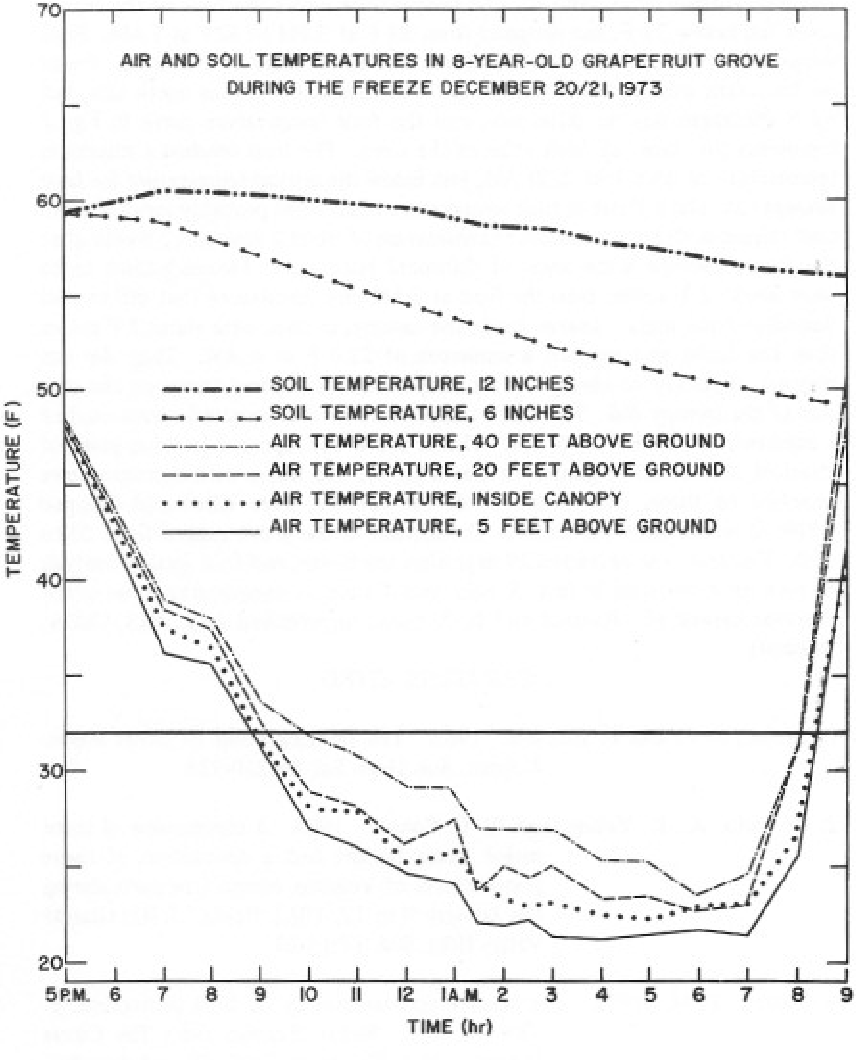

Fig. 1. Air temperature inside the canopy shows the mean of measurements in two trees; all other air temperatures and soil temperature are based on one thermocouple.

Tree-tissue temperatures (Fig. 2) followed the pattern of changes in ambient temperature in dropping rapidly until about 1 AM. Then they leveled off and rose sharply after sunrise. The temperature under the bark of the trunks never fell below 32 F, but dropped from 53 F at 5 PM to 32 F at 7 AM. Fruit temperature was measured on the north and south sides of the trees. Fruits on the south side were 4 F warmer at 5 PM than fruits on the north side, but by 8 PM there was no difference, and the fruit temperature curve in Fig. 2 represents the mean of both sides of the trees. The fruit reached a minimum temperature of 25.5 F at 2:30 AM, just below the critical temperature for fruit damage (2). The 1 F rise in fruit temperature after 3 AM probably resulted from heat release with ice formation. Examination of fruits 2 days and 2 weeks after the freeze showed some areas of disrupted juice sacs. Two-inch-thick limbs were about 2 F colder than the fruit at 5 PM and maintained that differential throughout the night. Leaves inside the canopy, in turn, were about 2 F colder than the limbs and reached a minimum of 22.6 F at 4 AM. They did not respond as readily to changes in air temperature as exposed leaves on the outside of the canopy did. The mean temperature of four exposed leaves reached a minimum of 20.5 F at 5 AM. This is below the reported freezing point of attached and detached grapefruit leaves (1, 4). All leaves with thermocouples attached to them, except one inside the canopy, were killed and dropped within 2 weeks after the freeze. Defoliation in the grove ranged from 20 to 35%. The fruit was harvested 19 days after the freeze, and fruit quality analysis showed no differences in Brix, % acid, and % juice, as compared to those of the previous harvest (C. Wiegand and B. J. Lime, unpublished data, ARS, USDA, Weslaco).

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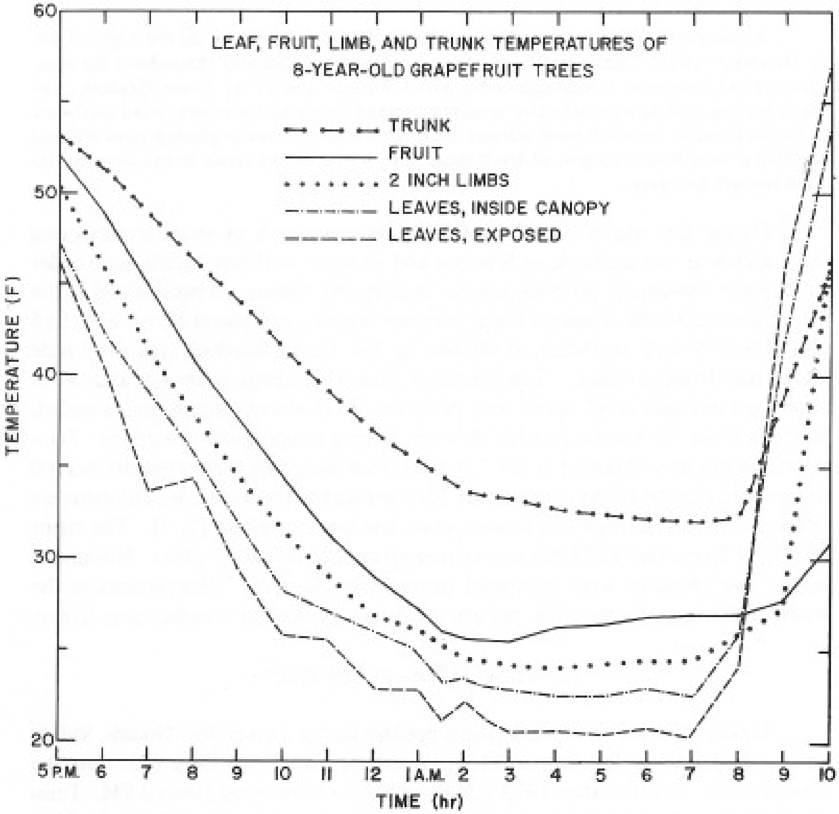

Fig. 2. Leaf and fruit temperatures are based on two leaves and fruits on each of two trees. Limb and trunk temperatures represent one measurement per tree.

Effects of Conventional Cold Protection Systems In a Radiational Freeze

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ABSTRACT

A radiational freeze occurred in the Lower Rio Grande Valley on the night of 20, 21 December 1973. Minimums in the low twenties were common throughout the area. Temperature inversions at midnight were 5F at Weslaco and 7F at Texan Gardens. Orchard heating devices were effective in raising orchard temperatures as were wind machines. Orchards recently irrigated were warmer than dry orchards. Newly-planted trees without protection were frozen to ground level; those with polyurethane trunk wraps were not injured beneath the wraps.

During the winter months we maintain a network of weather measuring instruments in our orchards at Weslaco and at some outlying locations in order to monitor conditions on cold nights. Instrument towers are maintained at the Citrus Center South Research Farm between Weslaco and Mercedes on FM 1015 and Mile 5 N and northeast of Mission in the Texan Gardens area on 7 mile Road and Iowa Avenue. Temperatures from thermistor probes 5 and 50 ft above ground and wind speed and direction 25 ft above ground are recorded. Records from the towers provide data concerning temperature inversions. Temperatures are also obtained at the 5 ft level from recording thermographs located in standard Cotton Region Instrument Shelters within the orchards. Information obtained in this manner in previous years has been reported (2, 3). The night of 20, 21 December 1973 was one of damaging cold to Valley citrus. Minimums in the low twenties were registered throughout the area. Observations in the weeks following revealed the pattern of injury typical of a radiational freeze.

TEMPERATURE INVERSION

Under conditions of radiational cooling in the Lower Rio Grande Valley when temperatures fall below 34 F inversions usually develop (4). On the afternoon of 20 December 1973 a high of 52 F was reached about 3 PM. Temperature then began to drop at the rate of about 3 degrees an hour reaching 32 F before 10 PM. At sundown wind was northerly at 5 to 10 mph with the sky clear. About 10 PM wind direction became westerly with speeds less than 5 mph. Near midnight there was a period of about 10 min with gusts greater than 10 mph after which wind speed subsided to 2 to 5 mph for the remainder of the night.

In Fig. 1 temperature curves 5 and 50 ft above ground are shown for Weslaco and for Texan Gardens from 8 PM 20 December to 8 AM 21 December 1973. At both locations a difference of about two degrees F existed between the 5 and 50 ft level early in the evening with the temperature dropping at approximately the same rate. From 10 PM to midnight, at the 50 ft level, the rate of cooling slowed as wind speed slackened. Cooling near the ground continued, allowing the temperature inversion to strengthen. At midnight there was seven degree F inversion at Texan Gardens and a five degree one at Weslaco. Inversions useful for orchard heating existed until at least 6 AM.

ORCHARD HEATING

Inversions develop as the air layer near the ground continues to cool at a rapid rate while the temperature aloft tends to stabilize (Fig. 1). With an inversion present, temperatures near the ground are low, increasing the need for cold protection. Fortunately in the presence of an inversion most of the conventional cold protection measures function best.

With any type of orchard heating warm air rises, being cooled in the process. When the cooled, rising, air encounters a layer at the same temperature a circulation develops. With no inversion much of the rising warm air would dissipate its heat into space.

Fig. 2 shows the temperature curves at the 5 ft level for two adjacent orchards. Throughout the early night temperatures were similar with a difference of only 0.5 degree F existing between 1 and 2 AM. In one orchard we began lighting Dynaheat wax blocks (5) at 2 AM. The covers were completely removed so that the blocks were essentially spent after 4 hr. There were 120 wax blocks to an acre. One hour after lighting ambient temperature in the orchard had increased seven degrees. Temperature at the 5 ft level was maintained above 26 F for about 5 hr. In the unheated orchard temperature was below 23 F during this period with a low of 22 F.

WIND MACHINES

Wind machines depend on the presence of an inversion for their effectiveness. Warmer air aloft is mixed with colder air near the ground. In Fig. 3 temperatures 5 ft above ground 300 and 1000 ft from an 85 bhp wind machine are shown. At 2:30 AM when the wind machine was started there was an immediate upswing in temperature at the site within 300 ft of the wind machine while temperature continued to fall at the site 1000 ft away. Between 2:30 AM and sunrise at the site 1000 ft away from the wind machine, the tem-

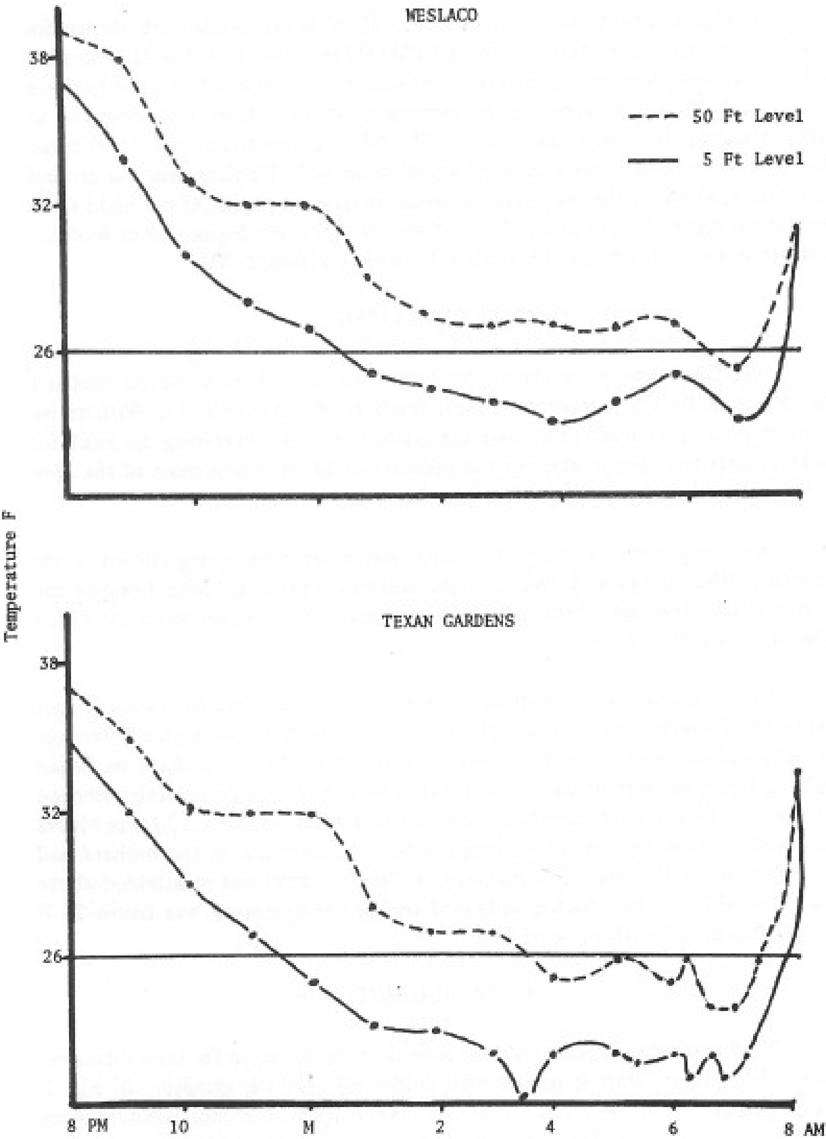

Fig. 1. Temperatures recorded 5 and 50 ft above ground during the night of 20-21 December 1973 at Weslaco and at Texan Gardens.

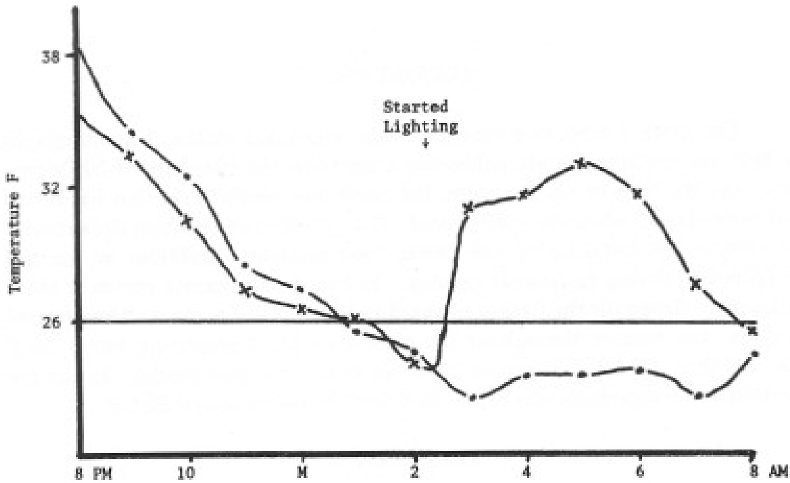

Fig. 2. Temperatures at the 5 ft level in adjacent orchards, one heated the other not heated, during the night of 20-21 December 1973.

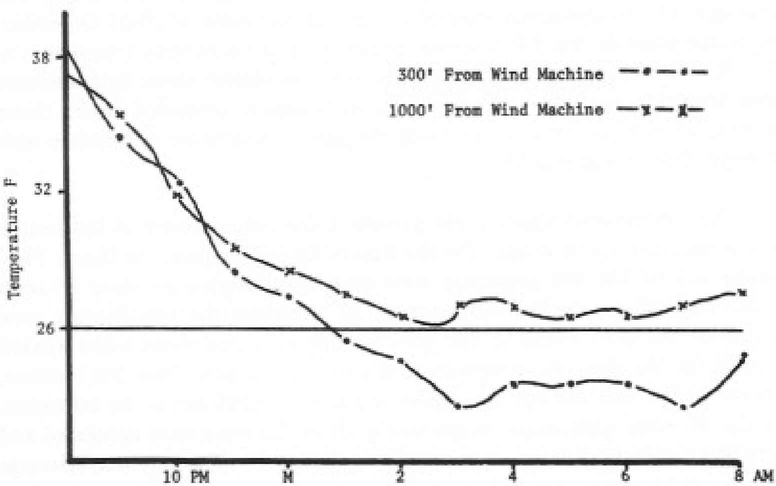

Fig. 3. Temperatures at the 5 ft level 300 and 1000 ft from an 85 bhp wind machine which was started at 2:30 AM on the night of 20-21 December 1973.

perature averaged about 23.5 F with a low of 22.5 F. On an area of about six acres around the wind machine temperature was maintained above 26 F during this time.

IRRIGATION

The south 5 acres of a ten-acre block, which had sheltered thermographs in both the north and south halves was irrigated on the afternoon of 20 December. On the basis of soil moisture, the north half needed irrigation but it had not been started when the cold arrived. This provided an excellent opportunity to observe the influence of two distinct soil moisture conditions on orchard temperature during radiational cooling. In Fig. 4 temperature curves at the 5 ft level are shown for the freshly irrigated and for the dry orchard. The irrigated portion was warmer throughout the night with the temperature below 26 F for less than 2 hr and a low of 25 F reached just before sunrise. In the dry portion, the temperature was below 26 F for 7 hr with a low of 22.5 F.

TREE WRAPS

Ten acres of grapefruit trees were planted on the South Research Farm during the last week of November 1973. Trunks were wrapped in the usual manner with polyurethane mats to provide insulation against wood-killing temperatures (1). In this newly-planted orchard on the night of 20-21 December, the temperature at the 5 ft level was below 26 F for 6 hr with a minimum of 22.5 F. Virtually all of the 1200 trees were defoliated; about half sustained some damage to exposed wood; there was no damage to protected trunks. Since we wrap all new trees routinely during the winter months no comparison with unwrapped trees was possible.

One commercial planting did provide a dramatic example of the benefit of polyurethane trunk wraps. On the Emory Owens property on Moore Field Road north of FM 681 grapefruit trees were being planted on about 60 acres in mid-December. On the afternoon of 20 December the tree-planting crew was about ten acres ahead of the crew putting on trunk wraps when worked stopped for the day. No temperature records are available from this location, however, trees that did not have trunk wraps were killed below the budunion. On the 50 acres with trunk wraps nearly all of the trees were defoliated and there was considerable injury to exposed twigs and limbs. The only wood damage beneath trunk wraps occurred on a few trees where wraps were very loose or where wraps were not seated on the ground. Where two or three inches of trunk was exposed at ground level trees were killed.

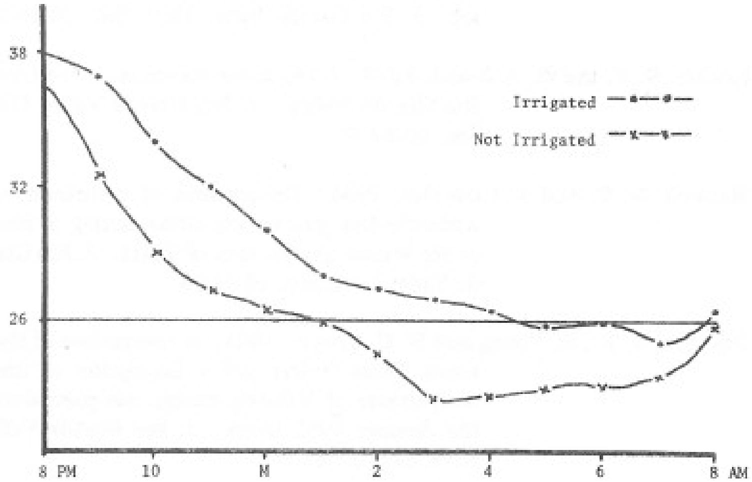

Fig. 4. Temperatures at the 5 ft level in freshly irrigated and not irrigated halves of a ten acre block of citrus during the night of 20-21 December 1973.

CONCLUSION

Most of the cold damage to citrus trees in the Lower Rio Grande Valley has occurred under conditions of radiational cooling (2, 4, 6, 7). The night of 20, 21 December 1973 was such a night. The greatest injury was sustained in the western end of the Valley, a lesser amount in the mid-Valley, and virtually none near the coast. As the foregoing observations indicate conventional cold protection systems can prevent or at least reduce the severity of cold injury in a radiational freeze.

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Assessing The December 1973 Freeze Damage In The Rio Grande Valley

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ABSTRACT

The leaf loss from freezing was compared to the percent fruit frozen, juice quality, bloom, new shoot growth and fruit set in five grapefruit and orange orchards. Freeze injury varied with location of the orchard and fruit variety. Leaf loss was proportional to fruit injury for grapefruit but not oranges. The percent juice decreased with increased fruit injury for grapefruit and early oranges but not Valencias. Soluble solids and acid increased with increased freeze injury in grapefruit. No relationship was evident between percent leaf loss and new shoot growth or bloom on the outside branches. The number of fruit set was related to amount of leaf and wood injury, for the whole tree but not individual branches.

Major freezes in citrus usually involve current and future crop losses and leaf, wood, and tree injury. Initial reports of freeze damage tend to be generalizations and highly qualified statements (1, 4, 15, 16). More detailed data on damage may appear 6 to 12 months later but this has little immediate value and usually lacks specific information on the affect on future production (3, 9, 11, 12, 18). Webber (17) noted slightly defoliated trees often set a larger crop than usual but most of the bloom produced on totally defoliated orange trees eventually dropped. He felt the amount of lemon fruit set in the fall was proportional to the amount of fruiting wood not killed in the previous winter's freeze. Hume (6) stated that citrus trees defoliated by a freeze seldom bear fruit the following season even though wood injury was minimal. Evidently unqualified and objective methods of rapidly estimating freeze damage to the current crop as well as the effect on next year's production are still needed. The freeze of 20-21 December 1973 provided an opportunity to evaluate some possible methods of damage estimation.

PROCEDURE

Data and observations were made in orchards at Texas A&I University Citrus Center, Weslaco and in Texan Gardens, about 35 miles NW of Weslaco.

During the December freeze the minimum temperature at the Citrus Center was 22 F with 4 hr below 24 F. In Texan Gardens the minimum was 20 F with 6.5 hr below 24 F. Other climatic features associated with this radiational freeze are described by Leyden and Hensz (8).

Frozen foliage was estimated and fruit samples taken 4-12 February 1974. Bloom and shoot growth were determined 8 February. The percent of wood frozen was evaluated in late April and fruit set in mid-June. Three to six trees in each orchard were sampled for foliage, wood and fruit damage. A fruit sample consisted of 6-10 fruit from each of four locations in the tree, top and bottom on both east and west sides. Fruit and juice analysis were run within 5 days of picking. Freeze damage in the fruit was expressed as the percent sections frozen. Separate counts were made for the stem and blossom/ or stylar end. Guidelines for determining freeze damage and juicing procedures were those described by Bartholomew et al. (2).

When applicable standard regression and analysis of variance statistical techniques were used (7).

RESULTS AND DISCUSSION

Freeze injury and orchard location. Freeze injury varied considerably between orchards, variety, and part of the tree (Fig. 1). The grapefruit orchard at Weslaco was heated with paraffin blocks beginning about 3:00 AM, 21 December. This undoubtedly reduced fruit injury but did not prevent leaves from freezing.

The radiational nature of the freeze and the absence of weeds in the orchards accounted for the consistently greater freeze injury to top than to bottom leaves and fruit (Fig. 2). The difference in foliage loss between the Valencia and adjacent Marrs trees at Weslaco (Fig. 1) could be due to age, the Valencias were older and taller; tillage, the Marrs were under chemical weed control; or variety. Although the Marrs fruit appeared to have more injury, 30-50% of the Valencia fruit had dropped by the time the samples were picked. Assuming this was the most severely damaged fruit, the Valencia figures represent fruit not frozen badly enough to abscise. Because Valencia fruit is less mature when freezes occur recovery from injury maybe better (9). There was no difference in freeze injury between the east and west sides of the trees.

Foliage loss and fruit injury. Estimates of damage to leaves can be made quickly and accurately a week or 10 days after a freeze. If foliage losses were

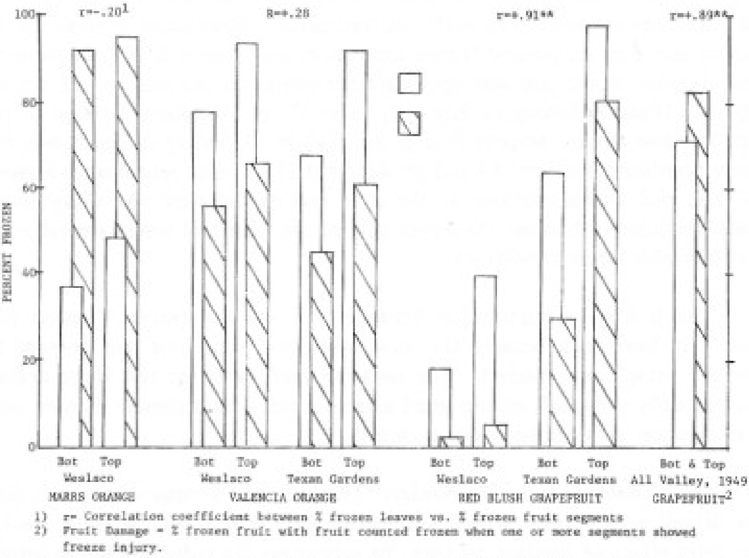

Fig. 1. Comparison of percent leaf loss and percent frozen fruit segments in Marrs and Valencia oranges and Redblush grapefruit.

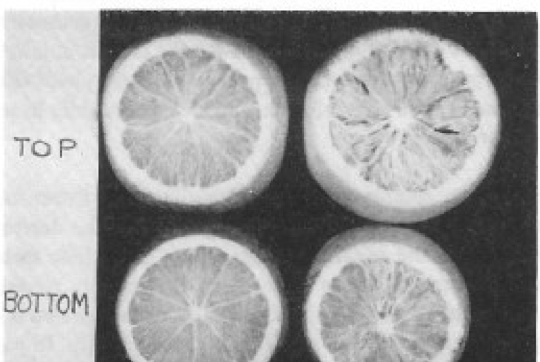

Fig. 2. Dried, ricey juice sacs and wavy section walls are evidence of freeze injury in Marrs oranges. The fruit from the top of the tree showed more injury than bottom fruit as did the stem end, right, compared to the blossom or stylar end, left.

proportional to the amount of fruit frozen, then damage to fruit could be indirectly determined from leaf loss estimates. Regression analysis of the percent leaf loss on percent frozen sections in the stem end, of fruit from the same location in the tree was significant for grapefruit but not for the oranges (Fig. 1). Using Rohrbaugh's data (10, Table VI, p. 187) the regression of percent leaf loss (x) on percent frozen fruit (y) in 11 Valley orchards was also highly significant with $r = .89$ and $y = 42.8 + 0.573\,x$. The relationship between leaf loss and frozen sections at the stem end of the fruit was always much closer presumably because the upper part of the fruit and leaves are subjected to comparable freeze conditions.

The lack of a relationship between leaf loss and frozen Valencia fruit again may have been because the most severely frozen fruit had dropped before the sample was picked. The negative coefficient for the Marrs oranges was probably the result of too small a sample and would change if more early or mid-season varieties had been included.

Freeze damage and juice quality. The presence of only one or two dried and off-colored sections would eliminate citrus fruit from the fresh market. The main effect of freezing on fruit for processing is a reduction in the percent juice (2, 5). For grapefruit and Marrs oranges the decrease in juice content was proportional to the increase in percent of sections frozen (Table 1). For reasons previously cited this did not hold true for Valencias. The relationship between the amount of frozen fruit and leaf loss should enable estimation of percent juice reduction. This calculation together with the change in juice content with time would permit processors to estimate post-freeze juice yields fairly accurately. The rate of decrease in juice content occurs much more rapidly in severely frozen than slightly frozen fruit (14).

The decrease in soluble solids (Brix) and acid in frozen oranges found by other workers (2, 3, 13) was not evident except for the decrease in percent acid in Valencias. On the contrary, in grapefruit both these factors increased with an increase in percent frozen sections. This probably relates to the time of the freeze. In normal winters, the December-January period is accompanied by a build up of sugars or soluble solids in Texas grapefruit. In partially frozen fruit this sugar is added to a smaller volume of juice sacs with a consequent increase in their sugar concentration.

Freeze injury, new shoot growth, bloom and fruit set. Trees defoliated by a freeze usually initiate new growth with the first prolonged warming trend. If new shoot growth and bloom is proportional to the degree of defoliation, then the number and length of new shoots and amount of bloom should be re-

Table 1. Juice characteristics as affected by freeze injury and location of fruit of Marrs and Valencia oranges and Redblush grapefruit.

JUICE CHARACTERISTIC	*MARRS ORANGES*			*VALENCIA ORANGES*			*REDBLUSH GRAPEFRUIT*		
	Bottom	*Top*[1]	*r*[2]	*Bottom*	*Top*	*r*	*Bottom*	*Top*	*r*
% Juice	30.7	26.0	-.78	46.5	42.6	-.13	52.6	49.7**	-.93**
% Soluble Solids (Brix)	11.0	10.8	-.50	11.8	11.4	-.03	9.43	9.56	.79**
% Acid	0.27	0.25	-.22	0.99	0.97	-.52*	1.03	1.00	.59**
Brix/Acid Ratio	40.7	43.8	.09	11.9	11.8	-.36	9.14	9.56	-.11
Specific Gravity	1.03	1.08	0.17	1.06	1.04	.12	1.04	1.03	.43*

1) * and ** indicate significant differences between top and bottom at the .05 and .01 level respectively.
2) r = correlation coefficient vs. percent frozen fruit section, * and ** indicate significant at .05 and .01 level respectively.

lated to the percent leaf loss. Inspection of individual branches, however, revealed no differences in shoot length or number between nodes with or without leaves frozen (Table 2). Leaf loss also had no effect on the number and earliness of bloom which was evaluated by the ratio of opened flowers to the total number of flowers and buds. The only significant positional effect was between outside and inside branches, the latter having no new shoot growth or bloom. Apparently the loss of dormancy following a freeze can be localized within the tree and occurs only when 25% or more of the leaves are lost. The nature of a radiational freeze would tend to create such conditions in the upper and outer canopy branches. Another influential factor was a light freeze in early February which killed many new shoots particularly in the west end of the Valley. Despite this February injury, I feel if a larger sample were taken some of these relationships might prove significant. The effect of frozen leaves and wood on the crop after the freeze was determined by calculating the multiple regression of percent leaf loss (x_1) and percent frozen wood (x_2) on fruit set (y) by location in the tree. For this calculation the data from the two grapefruit and the two Valencia orchards were combined. The resultant equation $y=28 + 0.275\ x_1 - 2.0\ x_2$ with a multiple correlation coefficient of .62 indicated a strong relationship between these factors. Applied to individual branches of the Marrs and grapefruit trees in Weslaco, however, the calculation showed no correlation.

Table 2. The relationship between leaf loss, new shoot growth, number and earliness of bloom on freeze injured Marrs orange and grapefruit branches.

	+ Leaf	*— Leaf*	*+ Leaf*	*+ Leaf*	*+ Leaf*	*– Leaf*
Percent Nodes with New Shoots	17	28	0	0	—[2]	—
Avg. Shoot Length (cm)	0.85	0.73	0	0	—	—
Percent Leaf Loss	74		32		91	
Number of Flower Buds	7.3		0		9.2	
Percent Open Flowers[3]	72		0		42	

1) + Leaf = leaf present and — Leaf = leaf dropped from freezing at each node counted.
2) Shoot data not recorded top branches.
3) Measure of earliness of bloom = no. of flowers/total no. flowers and buds.

CONCLUSION

1. Differences in leaf loss and frozen fruit between orchards were consistent with the type of freeze and temperatures reported from various parts of the Valley but Marrs oranges, grapefruit, and Valencias were not uniformly affected.

2. For grapefruit, a rapid and reasonably accurate estimate of freeze injury and subsequent loss of juice can be made from the percent leaf loss. Refining the sampling technique should increase the accuracy of the estimate and probably permit its application to oranges.

3. Higher soluble solids and acid were associated with increased freeze injury in grapefruit but not in oranges.

4. No obvious relationship was found between the percent leaf loss on individual outside branches and post-freeze shoot initiation and bloom. At the same time, however, inside branches which evidenced little freeze injury showed no new growth.

5. The number of grapefruit set (y) by location in the tree was related to the percent leaf loss (x_1) and percent wood frozen (x_2) by the equation, $y = 28 + .275\, x_1 - 2.0\, x_2$. No such relationship was shown for oranges.

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Evaluation of New Miticides for Control of Citrus Rust Mite and Texas Citrus Mite

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ABSTRACT

Several new miticides were screened on citrus for efficacy against the citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) and Texas citrus mite, *Eutetranychus banksi* (McGregor). Vendex or SD 14114 at dilute rates of 0.25 and 0.50 lb/100 gal and concentrate rates of 3.5 and 7.0 lb/acre gave effective control of both mites for 120 days. Vydate L (oxamyl) at 0.375 and 0.75 lb/acre gave good short term control of citrus rust mite but only after a fall application was it effective through 60 days post-treatment. In a test block of Ruby Red grapefruit which consistently had high rust mite populations, Comite at 0.25 and 0.40 lb/100 gal and Carzol (formetanate) at 0.10 lb/100 gal began to lose efficacy at 42 days. In a second block where there were lower rust mite populations, only the low rate of Comite lost efficacy at 42 days, while Comite at 0.40 lb and Carzol at 0.10 lb remained effective through 60 days. Definitive conclusions concerning the effectiveness of Vydate, Comite or Carzol against Texas citrus mite could not be made due to lack of mite populations in those blocks where these chemicals were tested.

The pest control program subscribed to by many Rio Grande Valley citrus growers requires 3-4 chemical applications, with the first applied just after petal fall and repeated at about 60-day intervals. Included in most sprays are one or more miticides for the control of citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) and Texas citrus mite, *Eutetranychus banksi* (McGregor).

Of the miticides currently in use some are effective against only one of the target species, e.g. chlorobenzilate (Acaraben) gives good control of citrus rust mite (RM) but is not particularly effective against tetranychid mites like Texas citrus mite (TCM) (4,7). Other miticides may control both species but have some complicating factor that limits their use. For example, carbophenothion (Trithion) effectively controls RM and TCM but can not be included in mid to late summer spray applications on grapefruit because it causes a rind-spotting disorder (6,7). Excessive or repeated applications of organophosphates like carbophenothion or azinphosmethyl (Guthion), which frequently replaces carbophenothion in summer spray programs, can cause surgance in populations of false spider mite, *Brevipalpus* spp. (1). Dicofol (Kelthane), another miticide effective on both species is used primarily in the fall or final cleanup spray. At present, its use is limited because at current recommended rates its cost exceeds that of other miticides. There are mite species which reportedly have developed resistance to dicofol (2,3).

Because of the limitations of many of the currently used miticides several new supplementary or replacement candidates were screened in efficacy trials primarily against citrus rust mite and secondarily against Texas citrus mite.

MATERIALS AND METHODS

Experimental chemicals were applied to citrus trees as either concentrate or dilute sprays. Concentrate application was by a John Bean Model F-357 CP speed sprayer (John Bean Division, FMC Corporation, Lansing, Michigan) with nozzle adjustment, pressure and speed of movement through the orchard regulated to apply 250 gal of spray per acre. A Hardie hydraulic sprayer (Hardie Manufacturing Company, Inc. Wilkes-Barre, Pa.) fitted with handgun attachment and operating at 550 psi was used for dilute application. Spray for small plots with limited number of trees was normally formulated in tank mixes of 100-200 gal and based on dilute rates of 1000 gal/acre. Foliage was sprayed to runoff ca. 15 gal per tree.

The chemicals used in these trials were: Carzol 95% SP (formetanate hydrochloride; m [[(dimethylamino) methylene] amino] phenyl methylcarbamate hydrochloride); Comite 75% E (2-(p-tert-butylphenoxy) cyclohexyl-2-propynyl sulfite); Vendex 50% WP or SD 14114 (distannoxane, hexakis (beta, beta-dimethylphenethyl)); Vydate L (oxamyl; methyl *N'N'*-dimethyl-*N*-[(methylcarbamoyl) oxy] -1-thiooxamimidate). In some trials Acaraben 4 E (chlorobenzilate; ethyl 4,4'-dichlorobenzilate) was included as a miticide standard.

Plot design, number and variety of citrus trees sprayed, and frequency of application varied between efficacy trials and are described under the chemical tested. With the exception of Vydate, which was tested in preliminary trials in 1972 followed by further tests in 1973, all other experimental chemicals were in trials during 1973. Efficacy of test chemicals against RM and/or TCM was determined by mite counts (pre-and post-treatment) on leaf and/or fruit samples from test plot trees. TCM counts were generally made by randomly collecting 10-20 mature leaves per treated tree at each sampling date, brushing the mites from the leaves onto counting plates with a Henderson-McBurnie mite brushing machine and counting at 20x under a binocular microscrope. In some trials counts were made in the orchard with the aid of a 14x hand lens. Either the number of mites per leaf were counted or percentage of leaves infested with RM or TCM per treatment sample determined. A leaf was considered infested if 2 or more live mites were found. In all trials, comparative mite counts were made on leaf or fruit samples from non-treated trees.

Citrus rust mite damage (russeting) was assessed on fruit from test plot trees at harvest in 1973. Fruit samples were randomly selected (20/tree) and rated as to severity of damage (free, mild, moderate or severe), with fruit in the free and mild categories equal to No. 1 grade, moderate as No. 2 grade and severe category useable as juice fruit only.

RESULTS

Spray trials with VYDATE L. Preliminary data on control of RM with Vydate was obtained from a trial on Webb Redblush grapefruit in 1972. Because this first short term trial (April-June) was conducted in conjuction with a nematicide experiment rather high rates of 0.25 and 1.0 lb ai/100 gal spray mixture (equal to 2.5 and 10.0 lb ai/acre) were used. Both rates gave effective RM control through 60 days post-application.

In 1973 expanded full season trials for RM control with Vydate at rates of 0.375 and 0.75 lb ai/acre were compared with chlorobenzilate at 1.5 lb ai/acre. A block of Webb Redblush grapefruit divided into 25-tree plots was used for spray trials. Each chemical rate was replicated on 4 plots. Initial application of test chemicals by the concentrate sprayer was made on 9 April with repeat applications on 23 July and 27 November. No additives were used in the 1st application; 12.5 gal of oil was added per 250 gal spray mixture in the second; and 1 pint of Surfactant NP (Niagara Chemical Division, FMC Corp.) added per 250 gal in the third.

RM populations were sampled pre and post-application; at each sampling date 10 fruit and 10 leaves were removed from the center 3 trees of each test plot and the percentage of samples infested by RM determined. RM infestations were non-existent in test plots until mid-July, at which time populations rapidly increased and control plots had sufficient numbers for comparative evaluations (Table 1).

Vydate at 0.375 and 0.75 lb rates gave good immediate control of RM. However, only after the third spray application did it control RM through 60 days post-application, at which time it compared favorably with residual effectiveness of chlorobenzilate (Table 1). No phytotoxicity was noted on test trees following any of the spray applications. RM damage on fruit was assessed at harvest in February, 1974. Fruit samples were taken (20/tree) from each of 4 trees in the center of each test plot. The highest percentage of damage-free fruit was harvested from the chlorobenzilate test plots followed in order by: fruit from Vydate 0.75 lb/acre test plots; Vydate 0.375 lb/acre plots; and the untreated plots (Table 2).

Table 1. Percent infestation by citrus rust mite of fruit and leaves sampled from Vydate and chlorobenzilate treated and untreated trees in test plots of Webb Redblush grapefruit.

	PERCENT RUST MITE INFESTATION[1]															
	Sprayed 4/9				*Sprayed 7/23*				*Sprayed 11/27*							
Treatment	*(-1)*[3]		*(30)*[4]		*(90)*		*(21)*		*(90)*		*(14)*		*(45)*		*(60)*	
And Rate[2]	*F*	*L*	*F*	*L*	*F*	*L*	*F*	*L*	*F*	*L*	*F*	*L*	*F*	*L*	*F*	*L*
VYDATE																
0.375 lb	0	0	0	0	14	26	0	0	45	30	2	3	0	3	3	3
0.75 lb	0	0	0	0	11	12	0	0	58	24	0	0	0	0	3	2
CHLOROBENZILATE																
1.5 lb	0	0	0	0	5	2	0	0	5	2	0	3	0	0	0	0
CONTROL	0	0	0	0	19	21	42	17	48	43	46	60	20	41	40	59

[1] Each chemical rate replicated on 4 test plots with percentage of infestation determined on 10 fruit (*F*) and 10 leaves (*L*) sampled from center 3 trees of each plot.
[2] Rate = ai per acre.
[3] Days before first application (pre-count).
[4] Days after last application.

Table 2. Evaluation at harvest of fruit sampled from trees in Vydate and chlorobenzilate treated test plots for russeting damage by the citrus rust mite.

		DEGREE OF DAMAGE[1]			
Treatment[2]	*Rate*[3]	*free*	*mild*	*moderate*	*severe*
VYDATE	0.375 lb	26	44	24	6
	0.75 lb	43	38	14	5
CHLOROBENZILATE	1.50 lb	81	17	1	1
CONTROL	-	18	39	28	15

[1] Twenty grapefruit were randomly harvested and evaluated from each of the center 4 trees of each test plot. Fruit samples were assessed for severity of mite damage and the percentage of fruit placed in each of the 4 evaluation catagories is given.
[2] Each treatment was replicated on 4 test plots and prior to evaluation at harvest (February, 1974) each of the plots had received 3 applications of test chemicals on 4/9, 7/23 and 11/27/73.
[3] Rate = ai per acre.

It was not possible to draw any definitive conclusions concerning the effectiveness of Vydate against TCM due to lack of populations throughout most of the season.

Spray trials with VENDEX (SD 14114). The following rates of Vendex were tested for control of RM and TCM:

Dilute Spray

1. 0.25 lb ai/100 gal water
2. 0.50 lb ai/100 gal water

Concentrate Spray

3. 3.5 lb ai/acre
4. 7.0 lb ai/acre

Each rate of Vendex was applied to 8 mature Valencia orange trees (Test block D-1) and 4 mature Ruby Red Grapefruit trees (Test block D-2) on 25 April 1973, with repeat applications on 19 June and 20 August. Additionally, Vendex in combination with citrus spray oil was applied to Ruby Red grapefruit trees to acquire both mite efficacy and tree phytotoxicity data. Two rates, 0.25 and 0.375 lb ai, were tested each combined with 1.5 gal spray oil per 100 gal of spray mixture. A single application was made on 19 June 1973 with mite counts and phytotoxicity data taken at intervals to 60 days post-application.

Vendex at all rates (dilute and concentrated) was very effective in controlling RM and TCM. Sprayed trees were virtually free of mites throughout the season while untreated trees in the test blocks had relatively heavy mite populations, particularly RM (Table 3). Following the third spray, 20 August, efficacy was maintained to 120 days post-application. Effectiveness of Vendex against RM was further substantiated by the high percentage of russet-free fruit obtained from sprayed trees at harvest (Table 4). A high percentage of fruit from the control trees showed moderate to severe russeting damage.

No phytotoxic reaction was observed on Ruby Red grapefruit trees sprayed with 0.25 or 0.375 lb of Vendex in combination with 1.5% citrus spray oil. No RM or TCM were found on treated trees at 24, 36, or 60 days post-application while untreated trees had high populations of RM and TCM throughout the trial.

Spray trials with COMITE and CARZOL. Comite at 0.25 and 0.40 lb ai/100 gal was directly compared to Carzol at 0.10 lb ai/100 gal for control of RM and TCM in trials conducted concomitantly in two test blocks of Ruby Red grapefruit. Utilizing a randomized block design 3 trees were sprayed with each rate

Table 3. Population of citrus rust mite (RM) and Texas citrus mite (TCM) on leaf samples from Ruby Red grapefruit and Valencia orange trees treated with various rates of Vendex and from untreated trees.

		MITE POPULATIONS[1]																	
			Sprayed 4/25					Sprayed 6/19				Sprayed 8/20							
		(-1)[3]		(14)[4]		(48)		(24)		(56)		(21)		(60)		(90)		(120)	
Treatment	Rate[2]	RM	TCM	RM	TCM	RM	TCM	RM	TCM	RM	TCM	RM	TCM	RM	TCM	RM	TCM	RM	TCM
Block D-2 (Grapefruit)																			
VENDEX	Dilute																		
	0.25 lb	25	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.50 lb	20	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Concentrate																		
	3.50 lb	10	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7.00 lb	5	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONTROL	-	-	-	12	4.5	45	6.2	87	1.5	35	6.3	17	0.2	42	4.4	70	2.0	71	0.2
Block D-1 (Oranges)																			
VENDEX	Dilute																		
	0.25 lb	5	2.1	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0.7
	0.50 lb	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	Concentrate																		
	3.50 lb	0	1.2	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
	7.00 lb	8	0.9	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
CONTROL	-	-	-	0	0.4	0	1.0	3	2.9	0	0.9	1.2	0.5	45	0.2	91	0.9	95	0.4

[1] At each sampling date two-10 leaf samples (10 leaves for *RM* infestation evaluations and 10 leaves for *TCM* counts) were collected from each treated tree. *RM* column represents percentage (%) of leaves infested with citrus rust mite. *TCM* column represents the mean number of Texas citrus mites per leaf.

[2] Dilute rate = ai per 100 gal of spray; concentrate rate = ai per acre. Each treatment rate applied to 8 mature Valencia (Test block D-1) and 4 Ruby Red grapefruit trees (Test block D-2).

[3] Days before first application (pre-count).

[4] Days after last application.

in each of the test locations (designated test block 1 and 2). Chemical application with the Hardie dilute sprayer was made on 11 July 1973 with mite population counts on grapefruit made to 60 days post-application. No oil, emulsifier or sticking agents were added to any of the spray mixes.

Table 4. Evaluation at harvest of fruit sampled from trees in two Vendex treated test blocks (Ruby Red Grapefruit and Valencia Oranges) for russeting damage by the citrus rust mite.

Location and Treatment[2]	*Rate*[3]	*DEGREE OF DAMAGE*[1]			
		free	*mild*	*moderate*	*severe*
Block D-2 (Grapefruit)					
VENDEX	Dilute				
	0.25 lb	97	3	0	0
	0.50 lb	100	0	0	0
	Concentrate				
	3.50 lb	95	5	0	0
	7.00 lb	98	2	0	0
CONTROL	-	0	3	20	77
Block D-1 (Oranges)					
VENDEX	Dilute				
	0.25 lb	100	0	0	0
	0.50 lb	100	0	0	0
	Concentrate				
	3.50 lb	100	0	0	0
	7.00 lb	100	0	0	0
CONTROL	-	10	30	38	22

[1] Twenty fruit were randomly harvested and evaluated from each of the sprayed trees in both blocks. Fruit samples from each treatment were assessed for severity of mite damage and percentage of fruit placed in each of the 4 evaluation categories is given.
[2] Each treatment was replicated on 4 Ruby Red Grapefruit trees in Block D-2 and on 8 Valencia orange trees in Block D-1. Prior to harvest (January, 1974) test blocks had received 3 applications of Vendex on 4/25, 6/19 and 8/20/73.
[3] Dilute rate = ai per 100 gal spray; concentrate rate = ai per acre.

Higher populations of RM were consistently found in test block 2 and both rates of Comite and the single rate of Carzol began to yield to heavy population pressure by 42 days post-application (Table 5). In contrast trials in test block 1, where there was less RM pressure throughout the post-application sampling period, showed Comite at 0.25 lb rate beginning to lose efficacy at 42 days, while Comite at 0.40 lb and Carzol 0.10 lb remained effective through 60 days. The resultant effect on fruit quality from heavier RM populations was evidenced by a higher percentage of grapefruit from test block 2 showing moderate to severe russeting (Table 6). However, it was apparent from treatment vs. control comparisons in both test blocks that a single application of either Comite or Carzol made-even as late as 11 July, significantly improved fruit quality at harvest.

Table 5. Percent infestation by citrus rust mite of fruit sampled from Comite and Carzol treated and untreated trees in two test blocks of Ruby Red Grapefruit.

Location and Treatment[2]	*Rate*[3]	*PERCENT RUST MITE INFESTATION*[1]				
		-1[4]	*14*[5]	*28*	*42*	*60*
Block 1						
COMITE	0.25 lb	20	0	0	23	37
	0.40 lb	10	0	0	0	3
CARZOL	0.10 lb	0	0	0	0	13
CONTROL	-	-	7	3	73	90
Block 2						
COMITE	0.25 lb	100	7	0	53	67
	0.40 lb	97	3	0	27	70
CARZOL	0.10 lb	97	0	0	23	70
CONTROL	-	-	27	20	100	100

[1] At each counting date 10 fruit per tree were checked for rust mite and percent infestation computed for all replicates of each treatment.
[2] All treatments made on 7/11/73 and each rate replicated on 3 trees in each block.
[3] Rate = ai per 100 gal spray.
[4] Days before application (Pre-count).
[5] Days after application.

TCM populations in both test plots were low throughout these trials and no definitive conclusions concerning efficacy of Comite or Carzol could be made.

DISCUSSION

All the miticidal candidates screened in current trials appear to have potential for controlling citrus rust mite. While only Vendex or SD 14114 showed efficacy against both species it was not possible to ascertain the effectiveness of the other miticides against Texas citrus mite since there were insufficient populations for reliable screening. This was undoubtedly due in part to the extremely wet conditions which prevailed throughout much of the 1973 season, more than 39 inches of rainfall recorded at Texas A&I University Citrus Center.

High moisture and humidity, favor development of citrus rust mite rather than Texas citrus mite which requires hot dry conditions for optimum life-stage development. While Texas citrus mite is not nearly as serious a problem on Valley citrus as is citrus rust mite there are advantages to development and use of miticides that give control of both species. Moreover, development and addition of new miticides to those presently in use allow for greater flexibility in choice of chemicals to meet continually changing control requirements, often resulting from variability in mite populations which exist not only between different Valley locations but also within individual groves where population changes can occur from month to month and season to season (5).

Table 6. Evaluation at harvest of fruit sampled from Comite and Carzol treated trees for russeting damage by citrus rust mite.

Location and Treatment[2]	*Rate*[3]	*DEGREE OF DAMAGE*[1]			
		free	*mild*	*moderate*	*severe*
Block 1					
COMITE	0.25 lb	83	8	7	2
	0.40 lb	91	6	3	0
CARZOL	0.10 lb	88	12	0	0
CONTROL	-	33	25	20	22
Block 2					
COMITE	0.25 lb	46	35	19	0
	0.40 lb	45	37	8	10
CARZOL	0.10 lb	68	19	7	6
CONTROL	-	0	7	22	71

[1] At harvest (December, 1973) grapefruit were randomly sampled and evaluated from each of the trees in the test blocks. Severity of mite damage was assessed for all replicates of each treatment and percentage of fruit placed in each of the 4 categories is given.
[2] Each treatment replicated on 3 trees in each test block on 7/11/73.
[3] Rate = ai per 100 gal spray.

ACKNOWLEDGEMENTS

The author gratefully acknowledges support of this research by grants-in-aid from E. I. DuPont DeNemours and Co., Shell Chemical Co., and Uniroyal Chemical.

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Citrus Mite Control With Certain Acaricides 1970-73

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ABSTRACT

The poorest residual control of Texas citrus mites was generally during the summer period. Banomite[R] provided about the same control of Texas citrus mites during 1971 as ethion and Omite[R] but failed to provide adequate control of citrus rust mites. During 1972 and early 1973, Vydate[R] gave about as good control of Texas citrus mites as ethion and generally these mites increased at an earlier date after Vydate than Omite. However, Vydate consistently gave poorer control of citrus rust mites than ethion or Omite. Ethion did not provide as good control of Texas citrus mites as Omite on several occasions but provided longer residual control of citrus rust mites than Omite. Formetanate gave about the same control of Texas citrus mites after a July application as ethion but poorer control after an October application. Control of citrus rust mites was excellent on both occasions in 1970 with formetanate and ethion. The poorest residual control of citrus rust mites was found with azinphosmethyl. False spider mites increased in numbers after azinphosmethyl.

Control of various mites has been of primary concern to the Texas citrus grower. The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), has been the number one pest while the Texas citrus mite, *Eutetranychus banksi* (McGregor), has varied considerably in its importance. False spider mites, *Brevipalpus* spp., were seldom of economic importance except following frequent usage of phosphate materials (2). The selectivity of certain acaricides in the control of these mites was considered in these investigations during the 1970-73 period.

MATERIALS AND METHODS

Spray materials were applied with a ground sprayer equipped with single nozzle guns, as well as with a tower gun above the tops of the trees using a total coverage technique (2).

Rates of materials shown in the tables are expressed in quantities of the following formulations per 100 gal of diluted mixtures: 22.2% EC azinphosmethyl (0,0-dimethyl phosphorodithioate S-ester with 3-(mercaptomethyl)- 1, 2, 3-benzotriazin-4(3H)-one) (Guthion); 75.0% WP Banomite[R] (Benzoyl chloride 2, 4, 6-trichlorophenyl)hydrazone); 45.5% EC chlorobenzilate (ethyl 4, 4' dichlorobenzilate); 42.0% EC dicofol (4,4'-dichloro-alpha-(trichloromethyl)benzhydrol) (Kelthane); 46.5% EC ethion (0, 0, 0', 0'-tetraethyl S, S'-methylenebisphosphorodithioate); 95.0% WP formetanate (m- [dimethylamino)methylene] amino phenyl methylcarbamate) (Carzol[R]); 99.65% 415 paraffinic oil (50% distillation point at 10 mm Hg (Orchex 696); 30.0% WP and 80.0% EC Omite[R] (2-(p-tert-butylphenoxy) cyclohexyl 2-propynyl sulfite); and 24.0% EC Vydate[R] (S-methyl 1-(dimethylcarbamoyl)-N-(methylcarbomoyl)oxy)thioformimidate). Sprint was added to the EC Omite to improve wetting.

The 2-tree plots were replicated 4 times with mite populations being determined from 40- leaf samples (20 from each tree). Plots were comprised of orange trees, except that all plot sets had a single tangerine tree and treatments A and C had a single grapefruit tree. Mature terminal flush leaves were randomly sampled 5-7 ft above the ground in each quadrant. Mites were brushed from the leaves onto a 5- inch plate with a mite-brushing machine and were counted on ½ the area with the aid of a stereoscopic microscope.

RESULTS AND DISCUSSION

Following application of the various materials on 28 July 1970, various mite populations remained relatively constant for 41 days until greater numbers of Texas citrus mites were found in formetanate plots than in oil-ethion or azinphosmethyl plots (Table 1). Citrus rust mites began to increase on 7 September and sharply increased 48 and 72 days after application of azinphosmethyl. False spider mites were present in these plots, whereas none were found in counts from other plots. Rain measurements were as follows: 0.03 - 10 September, 0.15 - 11 September, 0.29 - 12 September and 0.97 - 13 September. During the 19 September - 5 October period, a total of 8.04 inches of rain fell on 8 days throughout the period and were associated with a decline in Texas citrus mite numbers in all plots, although the decline was not detected in the oil - ethion plots on 14 September.

A steady increase of Texas citrus mites occurred after the application of formetanate on 13 October. Citrus rust mites and false spider mites were effectively controlled by dicofol. An increase in Texas citrus mites was not observed until 97 days after the oil - ethion application.

Table 1. Effect of spray treatments on populations of various mites.

Date	Days After Sprays	*A*[a]					*B*[a]					*C*[a]				
		TCM[b]	*TCME*[c]	*CRM*[d]	*FSM*[e]	*FSME*[f]	*TCM*	*TCME*	*CRM*	*FSM*	*FSME*	*TCM*	*TCME*	*CRM*	*FSM*	*FSME*
07/20/70		297	159	10	1	0	1,619	994	2	0	0	1,258	705	511	5	5
07/28[g]		6 oz formetanate					0.5 gal 415 oil + 8.8 oz ethion					23.6 oz azinphosmethyl				
08/19	22	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
09/07	41	355	325	0	0	0	248	372	0	0	0	63	150	48	15	7
09/14	48	177	287	1	0	0	278	463	0	0	0	16	51	1,133	53	72
10/08	72	156	109	1	0	0	98	64	1	0	0	16	20	2,567	18	9
10/13[g]		6 oz formetanate					0.5 gal 415 oil + 8.8 oz ethion					12.6 oz dicofol				
11/03	21	5	19	0	0	0	0	0	0	0	0	0	0	0	0	0
11/16	34	63	24	0	0	0	0	0	0	0	0	2	0	0	0	0
12/16	64	239	789	0	0	0	3	2	0	0	0	0	0	2	0	0
01/18/71	97	220	348	0	0	0	12	35	0	0	0	4	0	0	0	0
02/16	136	635	399	0	0	0	38	29	0	0	0	3	4	7	0	0
03/05	153	452	710	0	0	0	40	180	0	0	0	56	95	0	0	0

[a] Mites per 80 leaves; [b] Texas citrus mites; [c] Texas citrus mite eggs; [d] Citrus rust mites; [e] False spider mites; [f] False spider mite eggs; [g] Rates/100 gal.

Before the 19 May 1971 application, mite populations were greatest in the Banomite plots (Table 2). Texas citrus mites were reduced to small numbers in all plots possible at least in part as a result of 1.24 inches rainfall on 25 May. An increase was found 54 days after application, particularly in the plots; however, numbers of Texas citrus mites were as large or larger in the ethion - oil plots after 62 days. Citrus rust mites were found on the leaves in the Banomite and Omite plots after 54 and 62 days.

More uniform populations of mites were found in all plots on 20 July, except that no citrus rust mites were found on leaves from the ethion-oil plots. Following the applications on that date, an increase in Texas citrus mites was found particularly in the ethion-oil and Banomite plots. Mite numbers reached a peak after 62 days. Between 20 September and 30 September, rain fell on 8 of 10 days while rain fell on 8 of 20 days between 30 September and 20 October and seemed associated with a decline in numbers in all plots. The shortest residual control of citrus rust mites was found in the Banomite plots.

Citrus rust mites had increased to such an extent 44 days after the 27 October application of Banomite that chlorobenzilate was applied to these plots on 15 December. Citrus rust mites did not show an increase in numbers on leaves in Omite and ethion-oil plots until 23 February 1972. Counts on this date and the following two count dates totaled about the same in these plots. Texas citrus mite populations were increasing in numbers 68 days after the October Omite application. These plots consistently had greater numbers of this mite than other plots. Although little rain fell from 27 October through 28 December, relative humidity was quite high.

Counts before the 5 April 1972 sprays showed larger mite populations in the Omite plots (Table 3). The total of Texas citrus mites in the five counts after application was about the same in all treatment plots. Mite numbers were greater in counts 3 and 4 from the Vydate plots while greater numbers from the Omite and ethion-oil plots were found in counts 4 and 5 . Citrus rust mite numbers were larger from the Omite and Vydate plots that those from the ethion-oil plots.

The increase in Texas citrus mites began earlier after the ethion-oil application on 28 June than Vydate or Omite. The 1.04, 0.29, 0.16, 0.47 and 0.87 inches of rain that fell on 20-24 July may have been responsible for mites not having increased more during that period. Citrus rust mites were more prevalent after Vydate than Omite or ethion-oil.

Table 2. Effect of spray treatments on populations of Texas citrus and citrus rust mites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		TCM[b]	*TCME*[c]	*CRM*[d]	*TCM*	*TCME*	*CRM*	*TCM*	*TCME*	*CRM*
05/17/71		565	167	0	1,988	1,398	0	2,254	3,060	310
05/19[e]			1.5 lb Omite			0.5 gal 415 oil + 8.8 oz ethion			4 oz Banomite	
05/26	7	5	7	0	4	8	0	10	39	0
06/25	37	0	0	0	0	0	0	.1	0	0
07/12	54	50	56	23	23	47	1	17	29	75
07/20	62	78	129	21	86	240	0	50	47	35
07/20[e]			1.5 lb Omite			0.5 gal 415 oil + 8.8 oz ethion			4 oz Banomite	
08/02	13	0	1	0	2	9	0	5	36	0
08/16	27	.26	166	0	99	225	0	18	162	0
08/24	35	146	153	0	182	399	0	258	209	0
09/03	45	167	63	0	358	297	0	235	109	2
09/20	62	606	102	0	573	138	0	279	51	0
09/30	72	122	21	1	145	15	0	115	23	5
10/20	82	23	39	0	10	12	0	7	9	40
10/26	88	49	19	5	14	13	9	16	9	137
10/27[e]			1.5 lb Omite			0.5 gal 415 oil + 8.8 oz ethion			4 oz Banomite	
12/10	44	10	1	2	0	0	0	20	19	142
12/15[e]									6.3 oz chlorobenzilate	
01/03/72	68	48	0	2	2	0	0	17[f]	10	0
01/19	84	246	1	0	3	0	1	6[f]	1	3
02/23	119	51	25	10	5	9	35	6[f]	6	14
03/07	131	108	49	46	14	11	32	53[f]	15	20
03/29	153	301	88	74	48	20	53	50[f]	6	49

[a] Mites/80 leaves; [b] Texas citrus mites; [c] Texas citrus mite eggs; [d] Citrus rust mites; [e] Rates/100 gal; [f] 49 days less from last treatment.

Table 3. Effect of spray treatments on populations of Texas citrus and citrus rust mites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		TCM[b]	TCME[c]	CRM[d]	TCM	TCME	CRM	TCM	TCME	CRM
03/29/72		301	88	74	48	20	53	50	6	49
04/05[e]		1.5 lb Omite			0.5 gal 415 oil + 12.6 oz ethion			16.1 oz Vydate		
04/17	12	1	0	1	1	1	0	4	0	0
05/01	26	12	1	0	3	4	1	4	2	0
05/19	44	0	3	15	6	9	0	29	51	6
06/08	64	42	9	78	44	7	5	75	10	41
06/26	82	72	112	275	57	50	24	19	15	316
06/28[e]		1.5 lb Omite			0.5 gal 415 oil + 12.6 oz ethion			15.8 oz Vydate		
07/07	9	4	3	0	30	2	0	0	1	0
07/18	20	7	0	2	44	21	0	49	30	5
07/25	27	17	18	1	37	69	0	62	48	1
08/03	36	77	107	2	255	359	0	232	226	23
08/15	48	319	844	9	892	1,882	0	303	703	27
08/15[e]		6.3 oz Omite + 9.5 oz Sprint			12.6 oz ethion			15.8 oz Vydate		
08/30	15	10	46	0	351	1,696	0	151	1,008	2
09/14	29	20	36	0	687	967	0	206	424	25
10/04	49	661	838	37	599	825	0	418	279	113
10/16	61	1,726	211	1,074	686	169	0	385	152	676
10/17[e]		6.3 oz Omite + 9.5 oz Sprint			0.125 gal 415 oil + 12.6 oz ethion			15.8 oz Vydate		
10/31	14	16	27	0	28	42	0	68	126	31
11/07	21	11	21	21	20	83	1	37	79	39
11/14	28	62	8	41	241	33	1	203	30	183
12/05	49	6	102	17	63	167	2	75	338	98

[a] Mites/80 leaves; [b] Texas citrus mites; [c] Texas citrus mite eggs; [d] Citrus rust mites; [e] Rates/100 gal.

Texas citrus mites were reduced only 61 and 50% 15 days after the 15 August applications of ethion and Vydate. Large numbers of eggs provided for large mite populations. After 49 days, Omite-treated plots had larger numbers of Texas citrus mites that other plots. Citrus rust mites were found on all count dates after application of Vydate and their numbers were larger than that found in Omite plots except on 16 October. Rainfall records showed 0.04, 0.01, 0.12 and 0.01 inch on 16, 17, 19 and 20 September, respectively. Some reduced effectiveness of the materials may have been related to these small rainfall amounts.

Texas citrus mite numbers were larger in counts taken 14 and 21 days after the 17 October application of Vydate than ethion-oil or Omite. Mite populations were smaller on all count dates after Omite. Citrus rust mites were more numerous in counts from Vydate than ethion-oil or Omite plots on each of the four count dates. Some 0.33, 0.33 and 0.02 inch of rain fell on 19, 20 and 21 October.

Weather conditions were favorable for sharp increases in citrus rust mite populations in January 1973. Very high relative humidity occurred and rain fell on each day from 1-11 January for a total of 4.42 inches. Rust mites were numerous on fruit, and leaf counts did not indicate large numbers (as found on other occasions). Increases in citrus rust mite populations were evident 97 days after Vydate was applied on 31 January while small numbers were found after Omite (Table 4). Only two were found in the six counts after ethion was applied. A sharp increase in Texas citrus mite numbers were found 63 days after Vydate was applied while fewer mites were found in ethion and Omite plots. Rain fell on 9 days in February for a total of 5.99 inches and appeared to cause a decrease of Texas citrus mites.

Texas citrus mites began to increase sharply 36 days after Omite and ethion were applied on 30 May. Citrus rust mite numbers on the leaves were greater in Omite than ethion plots. On 20 June, 0.51 inch rain fell. Rain also fell on each of the following 6 days and totaled 6.29 inches for the 7-day period. These conditions probably delayed the increase of Texas citrus mites by 5 July, but were very favorable for the increase of citrus rust mites.

An earlier increase of Texas citrus mites was found after the application of ethion than after Omite following the 22 July treatments. Relatively small numbers found during this period were probably due to several days rain between each count date. Citrus rust mite numbers were more prevalent in the Omite than ethion plots. No acaricide was applied in plot C on 30 May and Omite was applied on 22 July.

Table 4. Effect of spray treatments on populations of Texas citrus and citrus rust mites.

Date	Days After Sprays	A[a]			B[a]			C[a]		
		TCM[b]	TCME[c]	CRM[d]	TCM	TCME	CRM	TCM	TCME	CRM
01/30/73		0	14	0	5	9	1	2	12	0
01/31[e]		6.3 oz Omite + 9.5 oz Sprint			12.5 oz ethion			15.8 oz Vydate		
02/09	9	3	1	0	0	1	0	0	0	0
03/01	29	1	0	0	0	0	0	0	0	0
04/04	63	1	2	0	0	0	0	38	46	0
05/08	97	5	14	7	24	30	0	115	279	64
05/23	112	27	64	3	11	15	2	263	684	71
05/29	118	84	123	22	123	96	0	930	[f]898	552
05/30[e]		6.3 oz Omite + 9.5 oz Sprint			12.6 oz ethion					
06/20	21	0	27	0	4	17	0	126	312	934
07/05	36	42	127	18	41	102	6	83	231	1,444
07/18	49	703	1,162	129	593	1,070	9	63	95	1,474
07/22[e]		6.3 oz Omite + 9.5 oz Sprint			12.6 oz ethion			6.3 oz Omite + 9.5 oz Sprint		
08/22	31	8	1	39	10	0	2	3	0	42
09/06	46	4	2	13	10	8	0	13	8	10
09/26	66	47	10	53	62	47	3	41	13	32
10/26	96	32	27	24	102	92	2	17	7	42
11/02[e]		6.3 oz Omite + 9.5 oz Sprint			12.6 oz ethion			4.1 oz chlorobenzilate		
11/21	19	2	7	0	67	62	0	1	4	0
12/19	47	5	3	0	48	8	0	23	23	13
01/11/74	70	69	29	18	76	206	0	14	12	1
01/30	89	74	64	65	381	274	6	64	46	12
02/12	102	61	86	100	83	130	13	22	41	0

[a] Mites/80 leaves; [b] Texas citrus mites; [c] Texas citrus mite eggs; [d] Citrus rust mites; [e] Rates/100 gal; [f] No acaricide applied.

Treatments were applied on 2 November because of the favorable weather conditions for increases of citrus rust mites. Texas citrus mites were more prevalent after applications of ethion than Omite or chlorobenzilate. Rainfall amounts were 0.01 and 1.94 inches on 5 and 6 November and may have been responsible for the lack of residual control by the various materials. Citrus rust mites were more prevalent in the Omite plots.

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Reflectance of Four Levels of Sooty-Mold Deposits Produced from the Honeydew of Three Insect Species

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ABSTRACT

Reflectance measurements showed that citrus blackfly, brown soft scale, and citrus mealybug were indirectly associated, respectively, with thinnest, intermediate, and thickest sooty-mold deposits on citrus leaves. Since reflectance decreased as the sooty-mold deposit increased, this verifies that remote sensing with photography is useful to distinguish among early infestations by these three insects.

Citrus blackfly (*Aleurocanthus woglumi* Ashby), brown soft scale (*Coccus hesperidum* L.), and citrus mealybug (*Planococcus citri* (Risso)) insects produce honeydew, which serves as a host medium for a sooty-mold fungus (*Capnodium citri* Berk. and Desm.). The sooty-mold deposits on the foliage are readily detectable with infrared color photography (5, 6, 7, 8, 9).

Citrus blackfly, brown soft scale, and citrus mealybug insects produce different amounts of honeydew (7, 9). Consequently, different levels of sooty-mold deposit result. This paper shows how the different levels of sooty-mold deposit produced from the honeydew of the three insects affected spectrophotometrically measured light reflectance.

MATERIALS AND METHODS

Mature orange (*Citrus sinensis* L.) leaves free from sooty-mold deposits and leaves lightly, moderately, and heavily coated with sooty-mold deposits were taken from groves each infested with citrus blackfly, brown soft scale, and citrus mealybug. The leaves were carefully wrapped in plastic wrap (Glad Wrap), stored on ice, and transported to the laboratory. (Mention of company name or trademarkis for the readers' benefit and does not consitute endorsement of a particular product by the U. S. Department of Agriculture over others that may be commercially available.) In the laboratory, five uniform leaves of each level of sooty-mold deposit for each insect were arbitrarily selected for spectrophotometric reflectance measurements. Measurements were made within 24 hr after the leaves were detached from the trees. The reflectance of leaves does not change within 48 hr if the leaves are wrapped in plastic wrap and stored on ice.

A Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment, was used to measure diffuse reflectance of upper (adaxial) surfaces of single leaves over the 500- to 2500-nm waveband. Data have been corrected for decay of the $BaSO_4$ standard (1) to give absolute radiometric data. With this instrument, a beam of monochromatic light of a desired wavelength can be placed upon a leaf. The reflected or transmitted light is collected by an integrating sphere and the intensity is measured by a photoelectric cell. The integrating sphere is coated with a nearly perfect diffusive reflector of light, $BaSO_4$. When an area of the sphere is illuminated, the diffusing material reflects the light omnidirectionally. A detector in the sphere surface measures the amount of light being reflected in the sphere.

Three wavelengths were selected from the 41 wavelengths measured at 50-nm increments over the 500- to 2500-nm waveband. Wavelengths selected were: 550 nm (green reflectance peak), 650 nm (chlorophyll absorption band), and 850 nm (on near-infrared reflectance plateau). These wave-lengths are within the photographic sensitivity range of infrared color film (3). Data for each of the three wavelengths were subjected to the analysis of variance (10), and Duncan's Multiple Range Test (2) was used at the 5% probability level.

RESULTS AND DISCUSSION

Figure 1 charts effects of four sooty-mold levels on citrus leaves indirectly associated with citrus blackfly, brown soft scale, and citrus mealybug on the reflectance of light over the 500- to 2500-nm waveband. As sooty-mold deposits increased from light to medium to heavy, reflectance progressively decreased, compared with no sooty-mold deposit, over the 500- to 1450-nm waveband and generally increased over the 1450- to 2500-nm waveband. However, reflectance decreased most in the near-infrared waveband (750 to 1350 nm) --an important result because aerial infrared color film is sensitive to the 750- to 900-nm portion of the near-infrared waveband (3), and the 850-nm wavelength is a candidate band for discriminating purposes (4). As previously reported (5), sooty-mold deposits on citrus leaves cause black citrus tree images on aeiral infrared color transparencies compared with red images of trees with uncoated leaves.

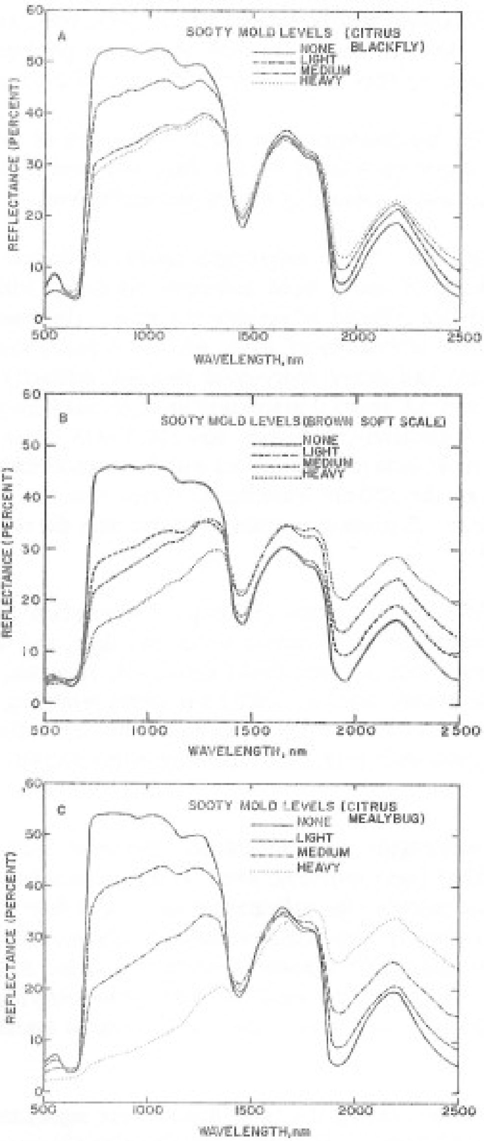

Fig. 1. Reflectance of citrus leaves with no, light, medium, and heavy sooty-mold deposits associated with citrus blackfly (A), brown soft scale (B), and citrus mealybug (C).

Further discussion will be limited to the 550-, 650-, and 850-nm wavelengths because they fall within the 500- to 900-nm photographic sensitivity range of infrared color film when a yellow filter is used to absorb blue light (3).

Statistically, the interaction of insects with levels of sooty-mold deposit was highly significant ($p = 0.01$) for the 550-, 650-, and 850-nm wavelengths, but Duncan's test was conducted at the 5% probability level.

Considering the 550-nm wavelength (green reflectance peak), medium and heavy deposits of sooty mold indirectly associated with citrus blackfly and citrus mealybug reduced reflectance the most. Decreases in reflectance, compared with the reflectance of leaves with no deposit, were 3.2 percentage units for medium and heavy sooty-mold deposits indirectly associated with citrus blackfly and 3.0 and 5.0 percentage units for medium and heavy sooty-mold deposits, respectively, indirectly associated with citrus mealybug. The levels of sooty mold indirectly associated with brown soft scale had little effect on reflectance at the 550-nm wavelength, except that the heavy deposit decreased reflectance 1.5 percentage units compared with the reflectance of leaves with no deposit.

At the 650-nm wavelength (chlorophyll absorption band), reflectance comparisons among the three insects within no, light, and medium levels of sooty-mold deposit were not statistically significant. However, the heavy sooty-mold deposit indirectly associated with the citrus mealybug significantly decreased reflectance (1.8 to 2.6%) compared with the reflectance of heavy sooty-mold deposits indirectly associated with citrus blackfly and brown soft scale.

Among wavelengths used, reflectance decreased most in the 750- to 1350-nm waveband (near infrared), which is represented here by the 850-nm wavelength. Statistically, the reflectances of no and light deposits of sooty mold for citrus blackfly and citrus mealybug were alike, but were higher than the no and light sooty-mold deposits of brown soft scale. At the medium level of sooty mold, the reflectances associated with citrus mealybug and brown soft scale were alike, but were lower than the reflectance associated with citrus blackfly.

All comparisons among the three insects were significant for the heavy level of sooty-mold deposit. The heavy deposit indirectly associated with citrus mealybug caused the largest reduction in reflectance. Highest percentage reductions in reflectance of leaves for the light, medium, and heavy sooty-mold deposits, compared with reflectance of leaves with no deposit, were: 37.2%

for the light deposit indirectly associated with brown soft scale, 57.1% for the medium deposit indirectly associated with citrus mealybug, and 86.7% for the heavy deposit indirectly associated with citrus mealybug.

Reduction in reflectance of citrus leaves increased as thickness of the sooty-mold deposit on the leaves increased. Brown soft scale was indirectly associated with the thickest light level of sooty-mold deposit, and citrus mealybug was indirectly associated with the thickest medium and heavy levels of sooty-mold deposit. When the average percentage reduction in reflectance for light, medium, and heavy compared with no sooty-mold deposits is considered, citrus blackfly, brown soft scale, and citrus mealybug were indirectly associated, respectively, with thinnest, intermediate, and thickest sooty-mold deposits. Field observations verify this relationship.

In remote sensing applications with aerial infrared color photography, images of infested trees appear blacker on transparencies, as the amount of sooty-mold deposit increases. Noninfested trees appear red. Therefore, remote sensing with photography might be used to distinguish among early infestations of citrus trees by citrus blackfly, citrus mealybug, and brown soft scale. Since the same sooty-mold organism is being observed with each insect species, the differences are probably related to rate and abundance of sooty mold deposited by each species.

ACKNOWLEDGEMENT

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

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An Outbreak of Sour Orange Scab in Texas

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ABSTRACT

An outbreak of sour orange scab caused by *Elsinoe fawcetti* was observed in a nursery near Brownsville, Texas following a period of high rainfall in 1973. The outbreak was localized and should not constitute a threat to Texas citrus orchards.

Sour orange scab was probably introduced into Florida from Japan on a shipment of budwood about 1875 (5). Subsequently it spread through citrus plantings on the Gulf coast (1) and was known to be present in Texas before 1923 (5). Fawcett (2) observed scab in a few orchards and nurseries in the Brownsville area in 1948, but no outbreaks have been reported since that time.

Sour orange scab, caused by the fungus *Elsinoe fawcetti* Bitancourt and Jenkins, produces raised, warty lesions on the leaves, twigs and fruit of susceptible varieties. Lesions are tan to pink at first, later becoming gray and crusty. Single-celled, hyaline spores, produced in acervuli on the surface of the scab lesions, are spread primarily by rain and by contact of implements with wet foliage. Infection is favored by high humidity or free moisture and temperatures between 60 and 75 F.

Leaves, twigs, and fruit are susceptible only when young and become immune as they mature. Sour orange (*Citrus aurantium* L.), lemons [*C. limon* (L.) Burm. f.], some tangelos (*C. reticulata* Blanco x *C. paradisi* Macf.) and other tangerine (*C. reticulata*) hybrids are severely attacked. Grapefruit (*C. paradisi*) is moderately attacked and sweet oranges [*C. sinensis* (L.) Osbeck] and Mexican lime [*C. aurantifolia* (Christm.) Swing.] are resistant or immune.

An outbreak of scab was observed in a citrus nursery near Brownsville, Texas in the fall of 1973. The crusty, raised lesions typical of the disease (Fig. 1A, 1B) were observed on nearly all of the sour orange seedlings in the nursery. Microscopic examination revealed the presence of acervuli and conidia typical of the asexual stage of the fungus *Sphaceloma fawcetti* Jenkins. Although damage was severe on the sour orange seedlings, little infection of the scion varieties was noted. Occasional infected leaves of grapefruit (Fig. 1C) and meyer lemon (*C. limon*) were encountered, but no symptoms were observed on sweet orange or Mexican lime. The extensive heavy rains in 1973 created favorable conditions for infection and spread of the fungus. Temperatures were somewhat warmer than those usually associated with outbreaks of scab. No mature sour oranges or other susceptible varieties were found in the vicinty of the nursery and the source of the infestation could not be located. Examination of sour orange trees near Brownsville and in other coastal areas revealed none that was affected by scab.

Scab probably does not constitute a serious threat to Texas citrus. Grapefruit is the only susceptible variety grown and, with the exception of the coastal area, rainfall is too low and the temperature too high for severe attacks of scab in grapefruit orchards. When scab becomes a problem on sour orange seedlings in the nursery, it can be controlled by applications of benomyl, ferbam, or a copper fungicide (3,4) to protect the new flushes of growth. Since the sour orange foliage is removed prior to transplanting, there should be little danger of introducing the disease into grapefruit orchards on the nursery stock. This risk can be further reduced by removing affected grapefruit leaves prior to transplanting.

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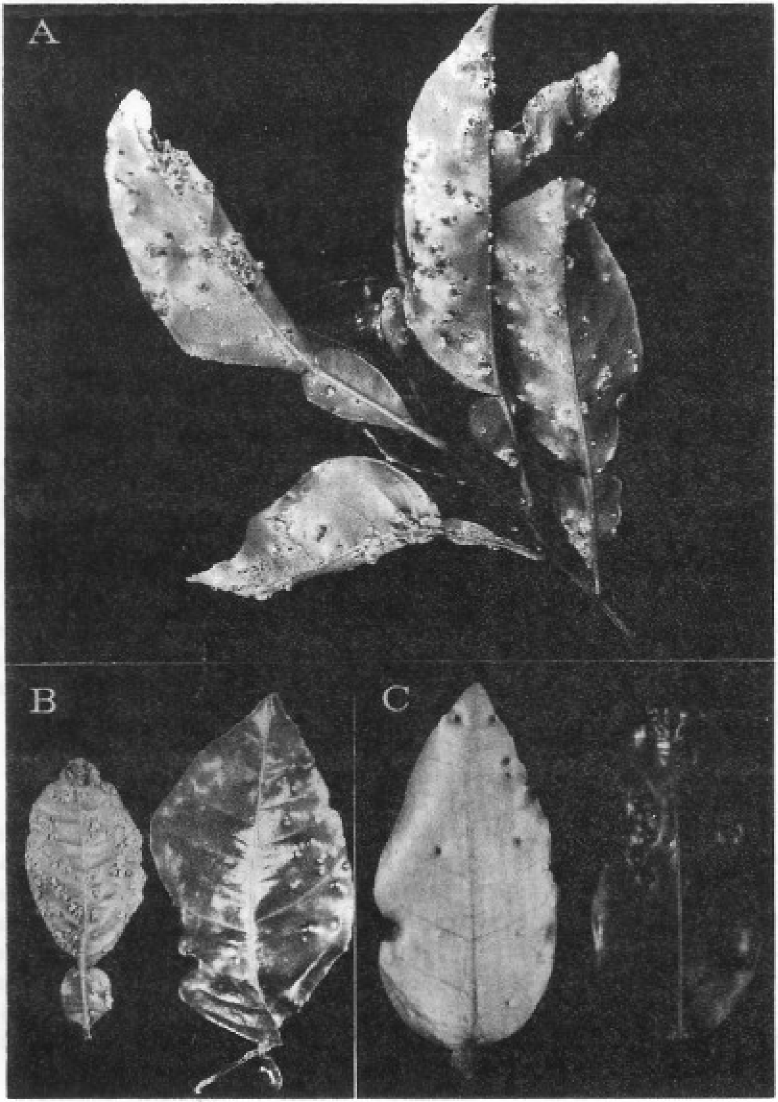

Fig. 1. Symptoms of sour orange scab. A) Severely affected foliage of a sour orange seedling. B) Raised, warty lesions on sour orange leaves. C) Infected grapefruit leaves with raised lesions on one side of the leaf (right) and indentations on the opposite side (left).

Grapefruit Seed Viability and Germination

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ABSTRACT

Beginning 1 July, grapefruit seed were removed from immature fruit, planted in peat-perlite medium and watered by mist. None of the seeds harvested before late August germinated, but after that time germination was nearly 100%. The average weight of the viable seeds was about 0.31 g.

Standard citrus references provide little information on seed viability and quality. Considering the importance of seedling rootstocks, very little research on seed characteristics as they relate to seedling vigor and subsequent tree physiology has been reported (3, 4, 7, 9). How early one may remove seeds from growing fruit and get germination is not mentioned in references on seedling propagation (2, 6, 8). With increased interest in growing seedlings in containers in greenhouses, the former emphasis on seeding after the danger of frost is irrelevant. Information on how soon seedlings can be started is more appropriate and this report addresses itself to that question.

PROCEDURE

At weekly or bi-weekly intervals beginning 1 July 1968, ten grapefruit were randomly selected from a 60-fruit sample taken from six mature Redblush trees. The fruit were assorted sizes from various locations within the tree. The seeds were removed, surface-dried, weighed, treated with Captan and planted within 24 hr. The seeds were sown in a 50% peat-50% perlite medium in mist propagation beds. Water was supplied by mist and heat cables maintained the temperature of the medium at 85 F throughout the germination period. Germination was determined at approximately weekly interby counting the number of emerged seedlings.

RESULTS AND DISCUSSION

The earliest date that grapefruit seeds would germinate was between 15 August and 1 September (Table 1). The disruption and consumption of the seeds planted on 15 and 22 August by rats precludes a more precise estimate of the earliest germination date. Apparently a certain threshold stage of development must be reached for the seed to be able to germinate. This threshold stage is attained at the same time by all seeds regardless of fruit size or origin within the tree. If this were not the case, one would expect a few seeds to germinate in mid-August followed by a gradual increase to 100% germination in late September.

Table 1. Weight and germination of grapefruit seed removed from fruit at different dates.

Date Removed	No. Seeds	Avg. Wt.	Cumulative Germination (%) Days after Planting 16-20	21-25	26-30	31-35	>40
6/27	27	0.118	0	0	0	0	0
7/11	44	0.193	0	0	0	0	0
7/18	46	0.239	0	0	0	0	0
7/25	30	0.283	0	0	0	0	0
8/1	33	0.257	0	0	0	0	0
8/8	35	0.303	0	0	0	0	0
8/15	30	0.327	0	0	0	0	0[1]
8/22	32	0.330	0	0	0	0	0[1]
9/5	30	0.328	60	67	80	97	97
9/12	43	0.337	12	46	54	98	98
9/19	28	0.309	-	25	61	68	100
9/26	27	0.354	11	33	59	100	100

[1] Rats destroyed some or all of these seeds.

The citrus industry is continually seeking earlier and more accurate methods of forecasting yields and harvest dates (1, 5). Since this threshold germination stage is quite abrupt, it might be a promising base for gauging fruit maturity and development.

Average seed weight might also be indicative of germinating ability. A weight of about 0.31 g appears minimal for germination of grapefruit seed. If further tests show sour orange behaves similarly, seeds sown as early as mid-August may germinate as well or better than stored seeds of the previous season.

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Potting Mixes and Fertilizer Tablets for Container Grown Citrus

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ABSTRACT

Sour orange seedlings were grown in four potting mixes containing various proportions of soil, sand, peat moss, perlite, calcined clay, and garbage compost. High N (28-8-4) and concentrated zinc (6-3-3 with 40% Zn) slow release fertilizer tablets were tested in combination with the potting mixes. Neither potting mix nor tablets affected stem growth. The number of new leaves was greatest on the 1/3 soil, sand, and peat moss mix and was almost doubled by adding one or one-half a high N fertilizer tablet. The addition of fertilizer tablets virtually eliminated the effect of potting mixes on shoot growth, but the concd zinc proved inferior to the high N tablet in this test.

A potting medium for container-grown citrus should provide sufficient nutrients, aeration, drainage and water retention for optimum growth. For commercial operations the medium should contain materials which are inexpensive, readily available, free of pathogens, reasonably stable and easy to handle (5).

While these requirements reduce the choice of materials and mixtures for growing citrus in containers in South Texas the potential number of media is still high. An ideal mix should include those materials meeting the above criteria which give the best tree growth. The modified UC mix, developed for container-grown citrus in California, uses 20-50% redwood shavings and requires fairly complicated liquid fertilizer additions (6). The lightweight soil-less mixes favored for ornamentals use high proportions of peat moss, perlite, vermiculite or wood shavings (2, 10). The high cost or unavailability of these materials and the irrelevance of light weight makes such mixes inappropriate for Texas citrus nurseries. Sour orange (*Citrus aurantium* L.), the rootstock used in Texas, is less sensitive to heavy soils and responds differently to fertilizer mixes and sources of peat moss than other citrus rootstocks (4, 8).

The present work was undertaken to provide more information specific to Texas conditions.

MATERIALS AND METHODS

The materials used in the potting mixtures were:

1. Hidalgo sandy clay loam - C.E.C. ca. 20 meq/100 g, pH 7.5-8.5
2. Comitas fine sandy loam - C.E.C. ca. 20 meq/100 g, pH 6.5-7.0
3. Washed builders sand, medium grain - C.E.C. ca. 1.0 meq/100 g, pH 8.1
4. Canadian sphagnum peat moss - C.E.C. ca. 160 meq/100 g, pH 3.6
5. Perlite, horticultural grade No. 6 - C.E.C. 0.1 meq/100 g, pH 7.2
6. Calcined attapulgite clay (PREP soil conditioner, Floridin Co., Pittsburg, Pa.) - C.E.C. 48-65 meq/100 g, pH 8.2
7. Garbage compost (METRO-ORGANIC 100, Metropolitan Waste Conversion Co., Wheaton, Ill.) - C.E.C. ca. 120 meq/100 g, pH 4.4

In the first phase of the experiment, 6 month-old sour orange seedlings were planted in 1.5 gal polyethylene containers with 12 seedlings in each of four potting mixtures. The mixtures were composed of equal parts by volume as follows:

Mix 1 - Fine sandy loam, sand, peat moss	pH 6.6
Mix 2 - Sandy clay loam, sand, peat moss, perlite	pH 6.7
Mix 3 - Calcined clay, sand, peat moss, perlite	pH 7.8
Mix 4 - Garbage compost, sand, peat moss	pH 6.6

The trees were grown outdoors under 30% shade from late March through mid-June 1968. Watering was done twice weekly by hose unless rainfall provided adequate moisture. In mid-June tree responses were evaluated by measuring stem diameters 2 inches above the soil line and counting the number of new leaves.

An evaluation of two types of slow release fertilizer tablets (Agriform Orchard Starter Tablets, Agriform International Chemicals Inc., Newark, Calif.) was made in conjunction with the potting mixture study. The *high N* tablet weighed 9 g and contained 2.5 g N, 0.31 g P, 0.36 g K, 0.18 g S, 0.09 g Fe, and 0.02 g Zn. The *concentrated zinc* tablets weighed 20 g and contained 1.2 g N, 0.26 g P, 0.6 g K, 8.0 g Zn, and 1.2 g S. At planting time four trees each in potting mixes 1 and 3 received half of a high N tablet and four more a whole tablet. The tablets were broken up and incorporated into the surface of the potting mixes. The effect of the tablets was evaluated along with the potting mixes in mid-June.

The second phase of this study, the addition of fertilizer tablets to the trees in potting mixes 2 and 4, was prompted by the obvious benefits of the tablets observed in the first phase of the study. In mid-June, six trees each in potting mixes 2 and 4 received a concd zinc tablet and the remaining six in each mix got one half a high N tablet. The tablets were applied as described above. The trees in mixes 1 and 3 received no additional fertilizer. In late November, the length of all shoots and the original stem length on each tree were taken as indices of growth responses.

Results were analyzed by standard statistical techniques including analysis of variance, Duncan's Multiple Range Test to separate mean differences, "t" test for paired means, and correlation analysis to evaluate relationships between two variables (7).

RESULTS

Without fertilization, the trees in potting mix 1 had the most new leaves, those in mix 4 the least and those in mixes 2 and 3 about equal number (Table 1). Adding fertilizer tablets almost doubled the number of new leaves produced in mixes 1 and 3 and made all means significantly different from each other. Neither potting mixes nor fertilizer tablets affected stem diameter which averaged 0.28 inch (0.68 cm) for all trees. The lack of any significant interaction between tablets and potting mixes indicated the increased leaf growth from the tablets was independent of the potting medium used.

Table 1. The effect of potting mixture and fertilizer tablets on the number of new leaves on sour orange seedlings from April to June.

Potting Mixture	*Fertilizer Tablets* 0	½	1	*Mean For Potting Mixture*[1]
1	19	38	39	32_d
2	8	—[2]	—[2]	8_b
3	9	22	16	16_c
4	4	—[2]	—[2]	4_a
Mean For Fertilizer Tablets[1]	8_a	30_b	28_b	

[1] Means in the same column or on the same line having a common subscript are NOT different at the 1% level of significance.
[2] No tablets were added to mixtures 2 and 4.

Based on the above results only a half of a high N or concd zinc tablet was added to the trees in potting mixes 2 and 4 for the second phase of the experiment.

The lack of any effect of potting mixes on shoot growth suggests the addition of the fertilizer tablets overcame the growth inequities present in mid-June (Table 2). The differences in shoot lengths between the four fertilizer treatments supports this assumption. For this length of time a half of a high N tablet was sufficient for good growth and was more effective than a half of a concd zinc tablet. Other than reduced tree growth no toxic effects of the high zinc application were evident. A "t" test of potting mix 2 vs. 4 and 1 vs. 3 gave no statistical differences between these pairs of mixes and indicated no interaction between the fertilizer tablets and potting mix. The possibility the whole high N tablet would have a longer residual effect was discounted by the lack of significant differences in shoot length between the one half and whole high N treatments applied in April. To determine if the tree condition in June might have influenced the November results a regression analysis of the number of leaves (June) on the length of shoots (November) was run and found to be non-significant. There were no differences in stem length associated with either potting mixture or fertilizer tablets.

Table 2. The effect of potting mixture and fertilizer tablets on total shoot growth (cm) of sour orange seedlings.

	TYPE AND APPLICATION DATE OF FERTILIZER TABLETS				
Potting Mixture	*½ N (April)*	*1 N (April)*	*½ N (June)*	*½ Concd Zn (June)*	*Mean Shoot Growth For Potting Mixes*[1]
1	73	101	—[2]	—[2]	92_a
2	—[2]	—[2]	81	43	64_a
3	52	80	—[2]	—[2]	70_a
4	—[2]	—[2]	103	47	78_a
Mean Shoot Growth For Fertilizer Tablets[1]	66_{ab}	90_a	92_a	45_b	

[1] Means in the same column or on the same line having a common subscript are NOT different at the 5% level of significance.
[2] No tablets were added to these mixtures on indicated dates.

DISCUSSION AND CONCLUSIONS

Without fertilizer sour orange seedlings grew best in potting media containing some soil. The seedlings did not do well in the primarily organic media (garbage compost-sand-peat moss) but grew better in the heavier mixtures containing soil or clay product. Fertilizer exerted a considerable influence but all growth differences were evidently not a matter of added nutrients only. In the first experiment, for example, the superiority of mix 1 over 3 must be due to some characteristics of the mix itself. The pH might have been one factor. Nauer, et al. (8) found growth was reduced and micronutrient deficiencies were increased on trees planted in mixtures whose leachates had pH's above 7.0. It is possible that the high water retaining capacities of the calcined clay and peat moss in mix 3 created a waterlogged condition. While Hagin, et al. (4) found sour orange seedlings to be less sensitive to poor aeration than Mexican lime, their sandy loam and loamy sand media significantly increased growth compared to low porosity clays.

One half of a high N tablet provides sufficient nutrients for good growth of sour orange trees in containers for at least eight months. While not evidenced by these tests, the possibility that a whole tablet would be beneficial for a longer period or in mixes with low exchange capacity should be evaluated in future tests. While symptoms of zinc deficiency occasionally appear in Valley orchards, adding zinc, especially at the concentrations present in the zinc tablets, is unnecessary, even detrimental, to potted citrus.

For commercial production of citrus trees in containers a potting mix that includes up to a third soil would seem desirable economically. Since long distance shipping would not be involved, the greater weight of soil mix would not be an important factor. Diseases or nematodes might be introduced with soil but fumigation could eliminate this problem. If the slow release fertilizer tablets produce growth equal to other fertilizing systems they would be a convenient and economical method for commercial use (1).

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Changes in Lycopene - Carotene Content and Fruit Quality of Hudson Red Grapefruit

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ABSTRACT

Seasonal changes in lycopene, carotene, Brix, and acid in Hudson red grapefruit and Redblush grapefruit were determined. Hudson had higher lycopene, Brix, and acid, and lower carotene than the Redblush throughout the processing season. Hudson appears to be a promising fruit for processing because of its high color and large size.

In the Lower Rio Grande Valley of Texas the predominant grapefruit (*Citrus paradisi* Macf.) variety is Redblush. Matlock (6) identified B-carotene and lycopene as the major pigments in Foster and Marsh Pink grapefruit. Kahn and Mackinney (5) showed this was also true for Redblush grapefruit. Lime et al. (4) and Purcell (7, 8) found the lycopene in Redblush grapefruit has a seasonal maximum and decline. The maximum for lycopene (7) is reached in mid-August or early September. Due to the decline of lycopene later in the season, red grapefruit used in processing from November through April does not have the most desirable red color. The processing industry is therefore looking for ways to improve the color of its red grapefruit products.

The Hudson Red grapefruit is a seedy red-fleshed variety. Hensz (1) states that the Hudson developed as a bud sport from the Foster Pink after freeze damage in the mid-30's. In late winter the flesh of the Hudson has considerably more red color than the Redblush variety. Preliminary work showed that late in the season the Hudson contained about three times as much lycopene as the Redblush variety. Due to the large number of seeds, Hudson has not been accepted for fresh market and so has not been planted extensively. The seeds of Hudson do not interfere with processing so this variety might be used to improve the color of processed red grapefruit products.

Star Ruby, a new variety of seedless grapefruit, originated as a mutation from Hudson (2). Our analysis of this variety in late season indicate the chemical composition is very similar to that of Hudson. In late March its lycopene content was about three times the level found in Redblush. Fruits have not been available to allow the seasonal determination of lycopene in the variety; however, lycopene trends determined in Hudson are expected to approximate those in Star Ruby. Therefore, we decided to determine the seasonal pattern of lycopene and carotene and to determine the fruit quality of the Hudson grapefruit.

MATERIALS AND METHODS

Five trees each of Hudson and Redblush growing less than 100 yards apart on the same soil type were used in the experiment. On each sampling date, fruits at eye level were picked from the north and south outer periphery of each tree. The fruits were washed, dried, weighed, and the albedo was carefully removed. Peeled fruits were weighed again and divided into three samples. Sample 1 contained four fruits and samples 2 and 3 contained three fruits each. The samples were blended in a Waring Blendor (Reference in this paper to specific commercial products do not constitute endorsement.) with three parts water to one part of fruit. Duplicate 100 g samples were analyzed for carotene and lycopene by Purcell's procedure (8, 9). Samples were also taken for Brix and acid determination. The data were treated by analysis of variance and the significance of differences between means was determined (3).

RESULTS AND DISCUSSION

In Redblush lycopene content reached its maximum on 19 September (Table 1), then started its seasonal decline. In Hudson the maximum lycopene content was reached on 10 October and then started to decline. The losses of lycopene in the two varieties after this date were similar until 12 December. From then until 17 February, the amount of lycopene in Hudson remained relatively constant. The rate of decline of lycopene in Redblush was not as great after 12 December as between October and December, while in Hudson the lycopene levels were higher than in Redblush from 10 October to the end of the test period. We have data (not published) for Redblush showing ^{14}C continued to be incorporated into lycopene even after the onset of the seasonal decline. Therefore, the higher level of lycopene in Hudson after the start of the seasonal decline could be explained by a higher rate of lycopene synthesis in Hudson than in Redblush, or a lower rate of lycopene destruction in Hudson than in Redblush, or to a combination of both.

Table 1. Lycopene and carotene in Hudson and Redblush grapefruit.

Date	Lycopene[ab] Hudson	Lycopene[ab] Redblush	Carotene[ab] Hudson	Carotene[ab] Redblush
7/25	1.98	1.92	0.15	0.10
7/8	1.89	1.85	0.13	0.11
8/22	2.08	2.12	0.15	0.12
9/6	1.89	2.15	0.15	0.15
9/19	2.08	2.24	0.20	0.21
10/10	2.23	1.92*	0.23	0.30*
11/14	1.41	0.98*	0.25	0.41*
12/12	0.97	0.63*	0.23	0.50*
1/23	1.02	0.44*	0.28	0.43*
2/27	0.94	0.35*	0.31	0.42*
3/28	0.66	0.22*	0.30	0.34

[a] mg/100 g fresh weight.
[b] Each item represents 10 fruits.
* Variety means significantly different at the 0.05 level.

The carotene content (Table 1) of Redblush increased until 12 December and then started a slow decline, while the carotene content in the Hudson increased slowly all through the test. On 12 December the concentration of carotene in Redblush was more than double that in Hudson. The larger amount of carotene with the rapid loss of lycopene causes the flesh of the Redblush to lose its red appearance and to take on an orange to yellow color, while the flesh of the Hudson remains red until early May.

Hudson had from 10 October slightly higher acid and from 14 November slightly higher Brix values than Redblush (Table 2). From 14 November, only slight differences were observed in the ratio of Brix to acid between the two varieties.

The Hudson fruit were much larger than the Redblush (Table 3). At the beginning of the experiment, Hudson was 30% larger than the Redblush, and at the end of the test was 39% larger. Because of its greater size, the Hudson could be used for chilled or frozen sections and other fruit products as well as for juice.

CONCLUSIONS

The Hudson grapefruit appears to be well suited for processing. The high lycopene and low carotene content of the flesh during the processing season gives it an attractive red color. The large fruit size and favorable Brix and acid also make the Hudson a desirable fruit for processing. Because of close genetic relationship Star Ruby should have the same characteristics as Hudson except for the absence of seeds.

Table 2. Comparison of fruit quality in Hudson and Redblush grapefruit.

	Acid %		*Brix*		*Ratio B/A*	
Date	*Hudson*	*Redblush*	*Hudson*	*Redblush*	*Hudson*	*Redblush*
7/25	1.44[a]	1.46[a]	10.5[a]	10.3[a]	7.2	7.1
7/8	1.34	1.42	9.9	9.7	7.4	6.8*
8/22	1.35	1.42	10.2	9.9	7.6	7.0*
9/6	1.31	1.38	10.6	10.0	8.1	7.2*
9/19	1.27	1.24*	11.0	11.1	8.7	9.0
10/10	1.30	1.15*	10.8	10.8	8.3	9.4*
11/14	1.15	1.03*	10.5	9.1*	9.1	8.8
12/12	1.15	1.09*	11.4	10.4*	9.9	9.5
1/23	1.16	1.07*	11.0	10.4*	9.5	9.7
2/27	1.12	0.97*	11.3	10.4	10.1	10.1
3/28	1.07	0.95*	9.8	9.5	9.1	10.0

[a] Each item represents 10 fruits.
* Variety means significantly different at the 0.05 level.

Table 3. Fruit sizing of the mesocarp of Hudson and Redblush grapefruit.

Date	*Hudson*[a]	*Redblush*[a]
7/25	129.6[b]	99.5[b]
7/8	170.6	92.0
8/22	227.8	106.4*
9/6	242.1	133.3*
9/19	260.1	151.4*
10/10	270.0	163.5*
11/14	403.7	244.2*
12/12	425.3	263.1*
1/23	454.7	291.7*
2/27	501.3	337.1*
3/28	564.2	405.6*

[a] Weight in grams.
[b] Each item represents 10 fruits.
* Variety means significantly different at the 0.05 level.

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Blending to Improve Quality of Texas Orange Juice Products

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ABSTRACT

Texas early-season orange juice and Valencia orange juice having individual Brix/acid ratios and colors which would not meet USDA Consumer and Marketing Service standards for Grade A products, can be blended to produce products which will meet such standards by proper selection of the blend components.

Since the 1962 freeze in the citrus-producing areas of South Texas, most of the orange crop has been used for processing primarily into single-strength juice, and more recently, into concentrate. The early season Texas oranges barely meet USDA Consumer and Marketing Service (C&MS) Grade A standards for canned single-strength juice, and concentrate for manufacturing, and seldom, and then only briefly, meet Grade A standards for frozen concentrated orange juice. Late season (Valencia) oranges are within the proper grade ranges for a longer period of time, but there are periods early in the harvest season when the acid is too high, and late in the season when the Brix is too high for Grade A concentrate.

Previous publications (1, 2) have reported the seasonal variations of Texas oranges, but did not relate maturity to processing characteristics. Also, subsequent to that work, the C&MS color standards were changed to include an OJ-6 color standard, and the older standards were altered at the same time. A study using current standards which are summarized in Table 1 was thus considered desirable. During the past several seasons, the Food Crops Utilization Research Laboratory of Weslaco, Texas has been studying the relation between maturity and juice quality for early-season, and Valencia oranges grown in the Rio Grande Valley of South Texas. Several trends have suggested that it might be possible to mix juices of lower grades in themselves, into blends which could make Grade A juice. This paper will report juice quality of orange varieties as related to maturity and suggest blends to up-grade the quality of juice products.

MATERIALS AND METHODS

During the five growing seasons from 1968-69 thru 1972-73 field-run fruit of Marrs, Hamlin, and Valencia oranges, grown commercially in South Texas, were harvested at intervals of two weeks from five groves representative of the growing conditions prevalent in the Lower Rio Grande Valley. The early varieties (Marrs and Hamlins) were picked from about the last week in September until the last week in March and Valencias from the last week in January until the first week in June. The fruit were washed on a set of brush rolls, dried, and the juice extracted with a Model 091B FMC in-line test extractor, fitted with 0.027-inch screens, and the small (No. 1) cup. Soluble solids were analyzed with a Bausch and Lomb Abbe refractometer, and reported as degrees Brix. Acid content was determined by titration with standard NaOH solution to pH 8.2-8.3, as determined by a Corning Model 7 pH meter and reported as % citric acid. Color was determined with a MacBeth Examolite, using OJ-6, -5, -4, -3, and -2 C&MS (3) standard tubes. The Brix/acid ratio was calculated from each lot of juice from each variety. Table 1 summarizes the limiting factors for U.S.D.A. Grade A orange juice and concentrate, when the OJ-6 tube is equivalent to a score of 35 points and the OJ-5 tube to 36 points (3).

Table 1. Limiting factors for USDA Grade A orange juice and concentrate

Product Type	*Color Score*	*Brix/Acid Ratio Limits*
Canned Single Strength	≤USDA tube OJ6[1]	10.5 to 20.5
Frozen Concentrated Orange Juice	≤USDA tube OJ5[1]	12.5 to 19.5

[1] USDA color tubes are ranked from tube OJ2 (highest color) to OJ6 (lowest color).

RESULTS AND DISCUSSION

Table 2 summarizes the data for Marrs oranges. The juice was within Grade A canned single strength orange juice (CSSOJ) standards for a period of four weeks. Color was the limiting factor in the early fruit while the Brix to acid ratio (B/A) was limiting later fruit. All color values for Marrs orange juice were below the tube 5 level, required for juice utilized for frozen concentrated orange juice (FCOJ) during the period when the B/A ratio was within limits of FCOJ standards (12.5-19.5).

Table 2. Seasonal variation in Brix, acid, and color of Texas Marrs oranges - Five year range and average.

Harvest	*Period*	*Brix* Avg.[1]	*Brix* High[2]	*Brix* Low[2]	*Acid* Avg.[1]	*Acid* High[2]	*Acid* Low[2]	*Ratio* (B/A)	*MacBeth* Color[3]
1		10.8	11.4	10.4	1.00	1.09	0.80	10.8	-6
2		10.8	11.5	10.2	0.81	0.87	0.73	13.3	-6
	Oct								
3		11.0	11.8	10.1	0.71	0.75	0.61	15.5	6
4		11.6	12.5	10.3	0.67	0.70	0.62	17.3	6
5	Nov	11.8	12.6	11.0	0.62	0.66	0.58	19.0	5.6
6		12.5	14.4	10.7	0.60	0.62	0.58	20.8	5.5
	Dec								
7		12.5	13.2	11.6	0.58	0.64	0.48	21.6	5.2
8		13.0	13.6	12.0	0.56	0.60	0.48	23.2	4.4
	Jan								
9		13.3	13.8	12.7	0.56	0.62	0.46	23.8	4.2
10		13.6	14.1	12.8	0.52	0.60	0.43	26.2	4.0
11	Feb	14.1	14.3	13.6	0.52	0.59	0.42	27.1	3.6
12		14.4	15.0	13.6	0.50	0.57	0.41	28.8	3.5

[1] Avg. values represent the mean of 25 analyses for each harvest period. Five analyses were conducted for each harvest period for five seasons.
[2] The extreme values recorded during the five-year period.
[3] The standards used for the MacBeth color range from OJ-2 (2) (highest color) to OJ-6 (6) (lowest color). Minus 6 indicates the juice color is not as good as the OJ-6 standard.

Table 3 summarizes data averages for Hamlin oranges. Color and B/A ratios indicate that Hamlins mature several weeks later than Marrs oranges. Canned single strength grade A orange juice may be prepared from these oranges during a 12 week period. Grade A FCOJ could be prepared in only one sample period because of color limitations. The color of the Hamlin oranges was a limiting factor in the early fruit, and a high B/A ratio in the last harvest periods.

Table 4 shows that with respect to color, Valencia oranges are within grade A standards limits for either CSSOJ or FCOJ during the entire harvest season. The B/A ratio is within limits of CSSOJ for about 18 weeks, and FCOJ for about 10 weeks.

A plot of the variation of the B/A ratio vs. time, as presented in Fig. 1, indicates that blending of the juices obtained can yield a mixed product which will meet grade A standards if the proper selection of juices is made. This is not readily obvious from the tables. The MacBeth color average is given at each sampling point. The limits of the B/A ratio for FCOJ for grade A standards are shown by the horizontal lines at 12.5 and 19.5 while the limits for the CSSOJ are represented by the lines at 10.5 and 20.5. Marrs oranges produce grade A CSSOJ for a period of about 6-8 weeks. This somewhat longer period than shown in Table 2 is indicated by extrapolation of graphing. Hamlins remain in grade 12-14 weeks, but color is consistently lighter than Marrs. Neither early variety would make grade A FCOJ due to color, except for Hamlin harvest period 10. Valencias remain in grade for CSSOJ for 16 weeks, and FCOJ for 10 weeks. The color is consistently within both grade limits during the harvest season. When the B/A ratio of early oranges is too high and Valencia too low, proper blending of the juices can give a mixture which will meet standards. Blending of 10% early Valencia oranges into the late-season Marrs and Hamlins is currently practiced in single strength juice processing in the Lower Rio Grande Valley.

With the recent expansion of the concentrate capabilities in Texas, interest in blending of concentrate to improve its quality has grown. Fig. 2, utilizing data obtained during the 1970-71 season, suggests blendings for concentrate. The 1970-71 season was regarded as a normal one, particularly from a climatic standpoint (no severe weather, including hurricanes; average rainfall and no damaging cold weather). The values plotted on Fig. 2 are averages from samples harvested at five locations for each period. For example, the products from areas 1E and 2V; and from 2E and 1V could be blended to produce FCOJ, which will be within grade limits. In these examples, frozen storage or other interim preservation would be required. Valencia juice could be held over and blended with early Marrs or Hamlin juice; or the latter could be held until

Table 3. Seasonal variation in Brix, acid, and color of Texas Hamlin orange juice - Five year range and average.

		Brix			*Acid*			*Ratio*	*MacBeth*
Harvest	*Period*	*Avg.*[1]	*High*[2]	*Low*[2]	*Avg.*[1]	*High*[2]	*Low*[2]	*(B/A)*	*Color*[3]
1		10.5	11.0	10.0	1.26	1.40	1.13	8.3	-6
2		10.3	10.8	9.9	1.05	1.16	0.92	9.8	-6
	Oct								
3		10.7	11.3	9.9	0.91	0.97	0.85	11.8	-6
4		11.1	11.5	10.2	0.86	0.94	0.74	12.9	-6
5	Nov	11.4	11.8	10.5	0.78	0.84	0.72	14.6	5.9
6		11.5	12.1	10.5	0.76	0.81	0.73	15.1	5.8
	Dec								
7		11.9	12.8	11.0	0.75	0.79	0.70	15.9	5.5
8		12.2	13.1	11.3	0.70	0.76	0.67	17.4	5.2
	Jan								
9		12.6	13.2	12.0	0.70	0.78	0.62	18.0	4.8
10		13.0	13.6	12.2	0.69	0.76	0.62	18.8	5.1
11	Feb	13.4	14.1	12.7	0.68	0.79	0.62	19.7	4.9
12		13.8	14.3	13.3	0.65	0.71	0.57	21.2	4.4

[1] Avg. values represent the mean of 25 analyses for each harvest period. Five analyses were conducted for each harvest period for five seasons.
[2] The extreme values recorded during the five-year period.
[3] The standards used for the MacBeth color range from OJ-2 (2) (highest color) to OJ-6 (6) (lowest color). Minus 6 indicates the juice color is not as good as the OJ-6 standard.

Table 4. Seasonal variation in Brix, acid and color of Texas Valencia orange juice - Five year range and average.

		Brix			*Acid*			*Ratio*	*MacBeth*
Harvest	*Period*	*Avg.*[1]	*High*[2]	*Low*[2]	*Avg.*[1]	*High*[2]	*Low*[2]	*(B/A)*	*Color*[3]
9	Jan	11.9	12.4	11.1	1.21	1.37	1.10	9.8	4.1
10		12.2	12.7	11.5	1.13	1.28	1.04	10.8	3.9
11	Feb	12.5	12.9	12.0	1.09	1.32	0.99	11.5	3.5
12		12.8	13.3	12.4	1.02	1.19	0.96	12.5	3.3
13	Mar	12.9	13.6	12.2	0.94	1.19	0.76	13.7	3.2
14		13.0	13.7	12.3	0.88	1.15	0.72	14.8	3.1
	Apr								
15		13.3	14.0	12.7	0.84	1.06	0.59	15.8	2.9
16		13.5	14.2	12.8	0.79	0.96	0.58	17.1	3.1
17	May	13.6	14.4	12.9	0.72	0.82	0.54	18.9	3.1
18		13.5	14.5	12.8	0.67	0.85	0.35	20.1	2.9

[1] Avg. values represent the mean of 25 analyses for each harvest period. Five analyses were conducted for each harvest period for five seasons.
[2] The extreme values recorded during the five-year period.
[3] The standards used for the MacBeth color range from OJ-2 (2) (highest color) to OJ-6 (6) (lowest color).

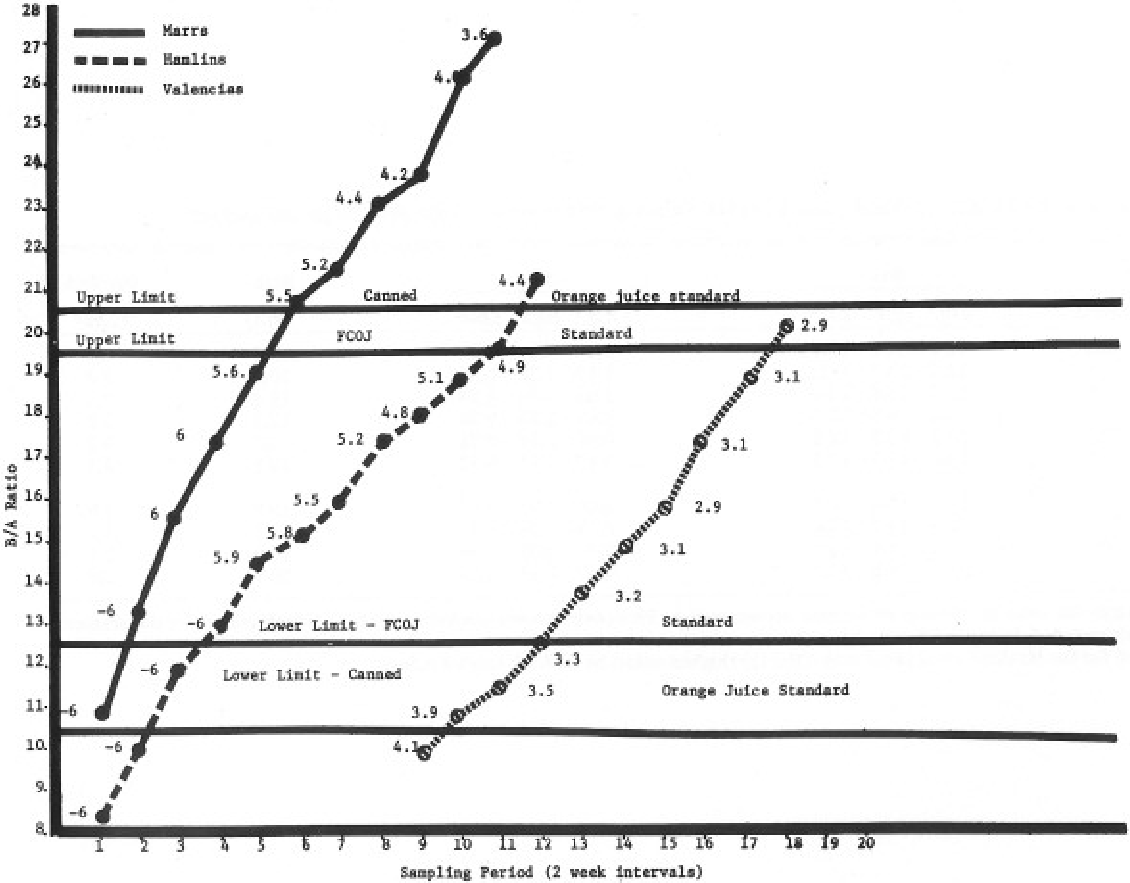

Fig. 1. Seasonal variation of the Brix/Acid ratio (5-year average) of Texas orange juice. C&MS Grade A standards limits superimposed. Average MacBeth color given at each sampling point.

late spring and blended with the high B/A ratio Valencia juice. A blend was prepared from 75% of a Marrs juice having a B/A ratio of 21.3 (area 2E) and a MacBeth color of 6, and 25% of a Valencia juice having a B/A ratio of 8.1 and a MacBeth color of 4-3 (i.e., better than the OJ-4 tube standard but not as good as the OJ-3 tube standard; area IV). The resulting blend had a B/A ratio of 15.5 and a MacBeth color score of 5. A second blend was prepared from 25% of a Hamlin juice having a B/A ratio of 8.5 and a MacBeth color of -6 (not as good as the OJ-6 tube standard; area 1E) and 75% of a Valencia juice having a B/A ratio of 21.4 and a MacBeth color of 3 (area 2V). The resulting blend had a ratio of 15.5 at 12.1 Brix and a color score of 4-5 MacBeth (not as good as the OJ-4 but better than the OJ-5 tube, and closer to 4 than to 5).

It will also be noted that in area 3, in the center of Fig. 2, the early season juice having a high B/A ratio can be blended as processed with low-ratio Valencia juice. In this area, all Marrs and Valencia color components are within grade A standards limits.

Other blends were prepared using 25%, 50% and 75% Valencia juice and the balance either Marrs or Hamlin juice. B/A ratios and color values for these blends were all within the Grade A range for FCOJ.

A number of large-scale concentrate tests involving blending were carried out at a commercial plant at Monte Alto, Texas. Pre-harvest field sampling, and analyses from 35 tons of early oranges having a B/A ratio from 19 to 25, and 34 tons of Valencias having a ratio of 9 to 11 gave an indicated blend having a B/A ratio of 14.6. The actual ratio obtained was 13.5. Although the blend was within grade, the variance between calculated and recorded ratios indicated the necessity for improved sampling; e.g., dock sampling. A second trial involved 44.5 tons of early fruit and 33 tons of Valencias. The fruit was sampled from eight trucks as it was unloaded. The predicted ratio was 15.9; the actual ratio achieved was 16.2. The color of all fruit was within grade for concentrate for manufacture so that no adjustments for this factor were necessary. Five-hundred forty barrels of orange concentrate were processed during this test period and gave 520 barrels of grade A blend, and 20 barrels of grade C product. The 20 barrels of grade C product resulted when Valencias were not available for blending. All other concentrates prepared by this plant during this test period were grade C products.

If the processing industry in the Lower Rio Grande Valley of Texas is to remain competitive, every effort should be made to upgrade all products processed. Proper juice blending practices offer excellent opportunities in this direction.

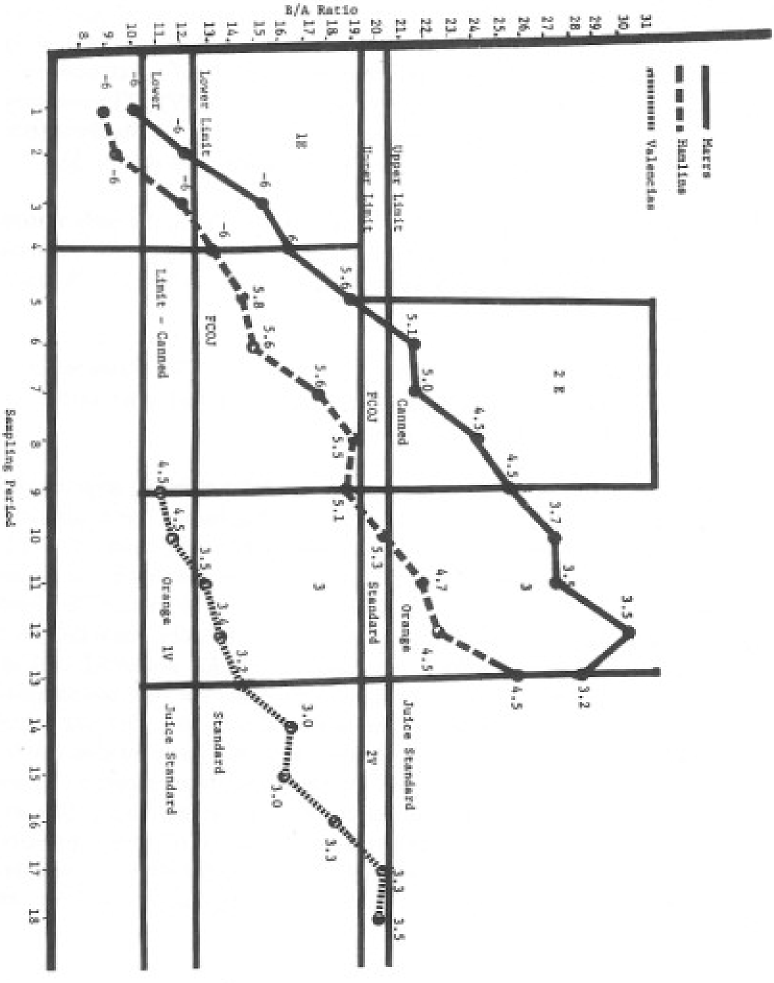

Fig. 2. Blending profiles of Texas orange juice (1970-71 season). C&MS standards limits superimposed. Average MacBeth color indicated at each sampling period.

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Note: Complete sets of tables of analytical data obtained during this 5-year study are available as a separate reprint upon request.

Application of the Citrus Colorimeter to Texas Orange Juice

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ABSTRACT

The Hunterlab Citrus Colorimeter tended to give somewhat higher color scores than the USDA Orange Juice Color Standards on Juice from the three major commercial varieties of Texas oranges. Subjective judgement of the color scores, inherent in the use of the color standards was eliminated. The possibility of a re-evaluation in the conversion formula of Huggart et al., now used in Florida, as applied to raw scores from the Hunterlab instrument on Texas orange Juice was discussed.

The Hunterlab Citrus Colorimeter has been evaluated in Florida for several years (1, 2, 3, 4, 8) as a means for the determination of color of processed orange products; it is now an official method of the Florida Dept. of Citrus for measurement of color for orange products. (Use of a company and/or product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.) Also, the U.S. Agricultural Marketing Service (AMS) in Florida has utilized the citrus colorimeter for grading futures concentrates. Although the instrument is not now used by the Texas citrus industry, the recent regulations adopted in Florida, making color measurements with the instrument mandatory for all orange products originating or processed in that state suggest that the instrument eventually will be used in Texas. This study was initiated to compare color values obtained by the AMS procedure with the orange juice color standards (5, 6, 7) and values obtained from the citrus colorimeter. A second objective was to evaluate with a Texas orange juice the formula developed in Florida for converting the citrus colorimeter CR and CY values into equivalent color grade points in the AMS standards for orange products.

MATERIALS AND METHODS

Juice samples were obtained biweekly from Marrs, Hamlin and Valencia oranges from five groves representing the major citrus producing areas of

South Texas. The juice was extracted with an F M C Model 091 B in-line test extractor, fitted with 0.027 inch screens, and maintaining 18 psig air pressure on the pulp outlets. The juice was deaerated at 30 inches vacuum. Color values were obtained using a Model D45 Hunterlab Citrus Colorimeter, standardized with an 0J4 tube standard; and a MacBeth Examolite Model EBA-220 using the revised USDA color tube standards 0J-1 thru 0J-6. Visual color scores were determined by the use of the MacBeth Examolite, as outlined in the U.S. Standards for Grades of Frozen Concentrated Orange Juice where tube No. 5=36 points and tube No. 2=40 points (6). Hunter colorimeter scores were calculated from the formula developed by Huggart, et al. (3) where point scores = 22.510+0.165CR+ 0.111CY. CR and CY are the respective red and yellow readings from the citrus colorimeter.

Arrangements were also made with the Inspection Office of the AMS, Weslaco, Texas, to furnish samples of commercial juice with the indicated score as assigned by their personnel. These samples were scored by both the AMS orange juice color standards and citrus colorimeter at the Food Crops Utilization Laboratory. This provided two independent visual readings on each commercial sample plus the colorimeter score. To determine the reproducibility of the citrus colorimeter, five samples covering the point score range from 33 to 40 were read at 30-min intervals. Five readings were made for each sample. The reproducibility of the visual color standards, using the MacBeth Examolite was compared using two separate visual readings by personnel familiar with the standards.

RESULTS AND DISCUSSION

Point scores assigned AMS color standard tubes are given in Table 1 for purposes of information and reference. The reproducibility of the colorimeter and visual determinations is compared in Table 2. The coefficient of variation (CV) indicated that differences between the two judges making the visual determinations were highly significant at the 1% level. Standard deviation and standard errors also indicate the variation was considerably lower with the Hunter instrument. The CV for the instrument readings was very low at all color levels indicating the high degree of reproducibility. The visual orange juice standard color scores ranged from 34 to 39 within the same range of the citrus colorimeter readings. The visual judgements showed much higher variation as indicated by the higher standard deviation and standard error.

Table 3 summarizes the color point scores of both procedures when applied to Texas orange varieties. Hamlins generate the least color of the three major Texas orange varieties. In four cases, the citrus colorimeter readings would have upgraded the juice from below 36 to above 36 points. One lot of late Hamlin juice would have been downgraded to below 36 points. Marrs juice develops a deeper color than the Hamlins, noted by the higher mean score. Citrus colorimeter determinations would have increased the USDA Grade of six samples of early juice; no downgrading was noted. Color scores of 39 points on juice from Valencia oranges were the same by visual procedures throughout the harvest season. No grade changes were effected by the citrus colorimeter score since all color scores exceeded Grade A. In the commercial samples, from a standpoint of color only, the citrus colorimeter would have upgraded four samples to above 36 points and downgraded two samples.

Table 1. Visual Color standards for FCOJ.[1]

USDA Color Tubes	*Score*
>0J6	32-33
=0J6	34
0J6 - 0J5	35
=0J5	36
=0J4	37
0J4 - 0J3	38
=0J3	39
=0J2	40

[1] Source - USDA Consumer and Marketing Service, Nov. 17, 1964 (Currently, Agricultural Marketing Service : AMS)

Table 2. Comparison and reproducibility of Hunter Colorimeter and MacBeth Examolite (Visual) color values.

Sample	*Type Instru-ment*	*No. of Observa-tions*	*Mean Score Points*	*Std. Devia-tion*	*Std. Error*	*Coefficient of Variation*
1	Hunter	5	33.2	0.09	0.04	0.27
2	Hunter	5	34.7	0.09	0.04	0.26
3	Hunter	5	39.9	0.05	0.02	0.13
4	Hunter	5	37.5	0.09	0.04	0.23
5	Hunter	5	36.1	0.09	0.03	0.25
6-45A[1]	MacBeth	40	37.0	1.43	0.23	3.86[2]
6-45B[1]	MacBeth	40	36.4	1.44	0.23	3.97[2]

[1] These samples consisted of 40 commercial samples independently visually scored by judge A and judge B. Color scores ranged from 34 to 39.
[2] Difference highly significant (0.01 level).

Table 3. Color scores-Texas orange juice, a comparison of colorimeter and visual methods.

Variety	*No. of Observ-ations*	*Mean Score AMS Color Standards*	*Mean Score Citrus Colorimeter*	*Degree of Variation*	*Times sample Upgraded by Citrus Colorimeter*[1]	*Times sample Downgraded by Citrus Colorimeter*[2]
Marrs	47	36.2	37.6	+3.6,-1.0	6	0
Hamlins	51	35.2	35.8	+2.4,1.8	4	1
Valencias	45	39.0	39.9	+2.8,-1.0	0	0
Commercial	44	37.3	37.5	+1.9,-2.8	4	2

[1] From below 36 to above 36 points.
[2] From below 36 to above 36 points.

Although there was considerably more variation in the visual observations, the variations between the two methods as shown in Table 3 (+1.4 point for Marrs, 0.6 for Hamlin, 0.9 for Valencia and 0.2 for the commercial samples) indicate that slight adjustment in the Hunter conversion formula might be needed for use on Texas orange juice. The variation of 0.9 point in the Valencias is somewhat surprising, since the color is well within Grade A standards at all times in the harvest season. Also, as indicated in Table 3, the variation of as much as +3.6 points (Marrs) to -2.8 points (commercial samples), using the official USDA Orange Juice Color Standards suggests that a slightly modified conversion formula might be desirable for Texas products.

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Ratoon Chlorosis of Sugarcane

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ABSTRACT

The economic feasibility of correcting ratoon chlorosis of sugarcane by spraying with iron sulfate was investigated. Two foliar applications of a 2½% solution (by weight) of iron sulfate effectively corrected iron chlorosis in NCo 310 sugarcane and significantly increased stalk and sugar yields by 68 and 71%, respectively. Since the cost of treatment ($1.75 per acre per application) is low relative to the yield increase, corrective treatments are definitely economically feasible.

Ratoon crops of sugarcane grown on soils in the Lower Rio Grande Valley of Texas often develop severe chlorosis soon after regrowth starts. Ratoon chlorosis is usually much worse on the sandy and sandy loam soils than on the clay soils. The areas affected vary in size and not all ratoon shoots within a single stool are affected. Ratoon chlorosis is caused by an iron deficiency and occurs in many sugarcane producing areas (4, 7, 8).

Soil properties that influence the solubility and availability of iron are pH, organic matter, and the oxidation-reduction state (2, 3, 5, 7). High base saturation of the clay minerals (pH 8) reduces iron availability. The chemistry of calcium and phosphorus are contributing factors: in the presence of phosphorus, calcium interferes with iron absorption and translocation. The decay products of organic matter may chelate iron, thereby decreasing its availability to plants. Under reducing conditions that prevail in high ground water areas, iron becomes more soluble and may leach out of the root zone. As with other crops such as soybeans and grain sorghum, sugarcane varieties differ in susceptibility to iron chlorosis.

Chlorosis first appears in sugarcane as pale green stripes between the parallel veins of the young leaves. In severely chlorotic cane, the areas between the leaf veins are pale cream, contrasting sharply with the green veins. Ratoon chlorosis is easily corrected by spraying young plants with iron sulfate. However, whether treatment to alleviate the chlorotic condition is economical must be determined under conditions in the Lower Rio Grande Valley. Iron-deficient cane, except in the advanced stages of deficiency, may recover naturally as the growing season progresses, but the delay in recovery reduces yields by an undetermined amount.

This study was conducted to determine whether iron deficient ratoon cane recovers without a significant yield loss, and the economic feasibility of spraying with iron sulfate solution.

MATERIALS AND METHODS

A severely chlorotic first ratoon crop of sugarcane (NCo 310) growing on Harlingen clay was selected for study. The experimental site was about 0.5 mile north and 0.5 mile west of Progreso in Hidalgo County, Texas.

In preliminary tests in 1971 and 1972 with foliar applications of ferrous sulfate and chelated iron, and a soil application (sidedressed) of 545 lb/acre of ferrous sulfate, only the iron sulfate spray corrected the chlorosis conditions of the ratoon cane. Therefore, in this study, we compared foliar application of ferrous sulfate (Copperas) with no treatment. (Trade names are given for the benefit of the reader and no endorsement or preferential treatment of one product over others that may be available is intended by the U. S. Department of Agriculture.) The treatments were randomly located on the experimental site and were replicated four times. Each plot consisted of six rows, 5.5 ft apart and 40 ft long.

A 2½% solution of iron sulfate (by weight) was sprayed on 10 and 17 April, using 20.9 lb of Copperas per 100 gal of water. The iron sulfate was dissolved in a smaller amount of water and passed through a screen to remove foreign material that could plug the spray nozzles. A wetting agent (1 quart of a mild household detergent) was added. Since the cane was only about 12 inches tall, one fan nozzle per row with 30 to 40 lb pressure thoroughly wetted the plant foliage.

The center portion (11 x 10 ft) of each plot was harvested by hand when the ratoon cane was about 10 months old. The number of millable stalks and total cane yield were determined. Juice was expressed from 20 stalk per plot and analyzed for apparent sucrose and total soluble solids (Brix). Purity coefficient and apparent sugar yields were calculated.

At harvest, leaves 3, 4, 5, and 6 (counting from the top downward) were collected from five plants in each plot. The middle third of the leaf blade was analyzed for total N by the Gunning method (1).

RESULTS AND DISCUSSION

When the study was initiated, characteristic symptoms of ratoon chlorosis suggested that 70 to 80% of the young leaves were severely affected by iron deficiency. Many of the leaves were in an advanced chlorotic stage as evidenced by the total lack of green color and by the brown leaf edges near the tip.

In response to the iron, small green spots developed on the leaves within 3 to 5 days after treatment. Young leaves with no green veins did not respond, so a second iron spray was applied. Leaves then recovered fully within 15 to 25 days. Cane not sprayed with iron recovered from the chlorosis later in the season, except that the most severely affected shoots died. Loss of stand affected stalk and sugar yields (Table 1).

Table 1. Effect of foliar applications of iron on cane and sugar yields, number of millable stalks, Brix, apparent purity, and sucrose content of juice.

	Yields of		*Millable*	*Apparent*		
Treatment	*Cane*	*Sugar*	*Cane*	*Purity*	*Sucrose*	*Brix*
	Tons/acre		Stalks/acre	%	%	
Control	23.8 a[1]	2.24 a	26,037 a	79.4 a	13.7 a	17.3 a
Iron spray	39.9 b	3.83 b	39,105 b	80.0 a	13.9 a	17.3 a

1) Values followed by same letter are not significantly different.

The application of iron increased the number of millable stalks by 50% and tonnage of stalks harvested 68% (23.8 vs. 39.9 tons). Mean stalk weights were 2.11 and 2.52 lb, respectively, on the control and iron treatments. The heavier stalks and the higher plant population resulted in significantly greater yields of cane and sugar for the iron-treated plots as compared with the control plots. Untreated cane was stunted. Weeds and grasses in the control plots also contributed to the lower yields.

Iron treatment did not affect juice quality. The relatively low purity may be due to the early harvest of this variety, and a high nitrogen (N) concentration within the plant. The N concentration in the 3 to 6 leaf blades (1.7%) was 0.4% higher than desirable for cane at this age (6).

The severity of the iron deficiency and the area involved are factors to consider in determining whether corrective measures should be applied. Stages in the development of ratoon chlorosis are shown in Fig. 1. Stools exhibit slight (A), moderate (B), and severe (C) symptoms of iron deficiency. The stools in frame C are approaching the advanced chlorotic stage, as is the field (D) of NCo 310 sugarcane grown on Hidalgo sandy clay loam.

Iron sulfate for application would cost about $0.84 to $1.67 per acre using 50 to 100 gal of foliar solution, respectively. Equipment and labor costs would be additional. Commercial applicators use 10 lb of material per acre for a total cost of $1.75. However, the volume of solution to be used per acre depends on stage of growth or quantity of plant foliage since the entire plant foliage must be thoroughly wetted for effective response. These low treatment costs relative to the yield increases suggest that preventive treatment would be profitable.

In this study, failure to correct the iron deficiency resulted in a 1.6-ton/acre sugar yield loss. Raw sugar was priced at $16 to $18 per 100 lb in early 1974. The additional molasses yield further increased the value of the iron spray. The reduction in plant population associated with the chlorotic condition will affect yields in subsequent years and may compel replanting sooner than was planned.

ACKNOWLEDGEMENT

The authors gratefully acknowledge Mr. Dick Garrett, Beckwith Farms Foreman, Progreso, Texas, for permission to conduct the experiment with a sugarcane crop on their properties.

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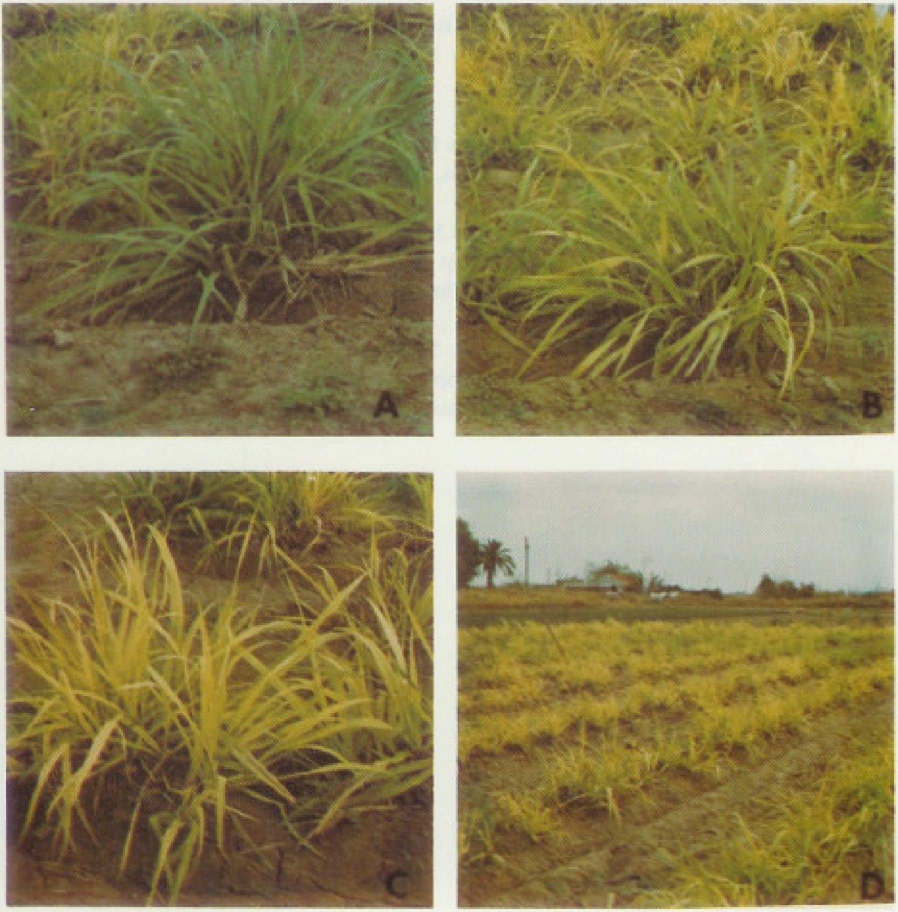

FIGURE LEGEND

Fig. 1. Stages in ratoon chlorosis development: Stools exhibit slight (A), moderate (B), and severe (C) iron deficiency symptoms in a field of NCo 310 ratoon cane approaching the advance chlorotic stage (D).

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The Potential of Soybean Cultivars For Commercial Production in South Texas

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ABSTRACT

Twelve soybean cultivars were evaluated according to yields, growth habits, and physical characteristics for production potential in the Rio Grande Valley Area of South Texas. Nine cultivars had bean productions of greater than 20 bu/acre with two cultivars producing around 35 bu/acre. The average plant height of Hampton-266A, Bragg, and F63-4000 was less than 20 inches which would present harvesting problems even though Hampton-266A produced the highest bean yields. Proteins, total carbohydrates, ash and lysine percentages of all cultivars were comparable to or within the range of values reported in the literature for field soybeans. Oil values tended to be slightly higher than those reported in the literature.

Soybean production in the United States is largely limited to the North Central States, South Atlantic States and Lower Mississippi Valley. In 1970 about 83% of the production was limited to 9 states, but some 30 states had commercial production (13). Areas of production have been determined largely by environmental factors which control the fruiting characteristics of the soybean. Yield is controlled by photoperiodic response to daylength during the growing period; thus, specific varieties produce best within a definite range of latitude.

Soybean seeds vary markedly in color, size, shape and in chemical composition. The physical and chemical differences are modified by heredity and by the climatic conditions in which they are grown. Piper and Morse (10) were among the first to note variations in oil and protein levels and of the iodine number of the oil. Changes in the fatty acid composition of the oil during seed development have been reported by Howell and Collins (5), who noted that those chemical changes in composition were sensitive to temperature. Percentages of linolenic and linoleic acid in the oil were inversely related to temperature within the range of temperature normally encountered in the field. Rinne (12) reported that temperature affected the incorporation of labeled acetate into fatty acids by a soluble preparation from developing soybean cotyledons. Cartter and Hopper (2) reported that differences in protein content in soybean could be due to variety, locality and to geographic area.

Since the chemical composition and physical characteristics of soybeans are subject to environmental, locality and varietal factors, we evaluated several varieties having potential in terms of yield, physical characteristics and chemical composition, for commercial production in the Lower Rio Grande Valley of the Texas.

MATERIALS AND METHODS

Twelve soybean cultivars were planted at the Texas A&M University Agricultural Research and Extension Center at Weslaco. The test site, having well-drained, sandy loam was sprayed with trifluralin (2, 6-dinitro-N-N-di-n-propyl-a, a, a-trifluoro-p-toluidine) for weed control, disked, and bedded into 40-inch rows and pre-irrigated. (The use of a company and/or trade name does not imply endorsement by the United States Department of Agriculture over others which may also be suitable.) Soybeans were planted 30 June 1972, with a a lister-type planter and during the growing period were sprayed for beet army worms once and irrigated twice. The test consisted of 4 replications in a randomized complete block design with plots 4 rows wide and 30 ft long. The two center rows, selected for yields, were hand harvested 14 November 1972, and threshed in a small-plot thresher.

Seven cultivars, which have shown some potential over past years for commercial production in the Lower Rio Grande Valley Area of Texas, were selected for chemical analysis. Selections were based on production records, growth characteristics and physical appearance.

Samples for chemical analyses were allowed to dry under ambient conditions, then ground in a Wiley Mill equipped with 0.10-cm screen. During grinding, a preponderance of the hulls remained in the mill after grinding and served as a method of partial de-hulling.

Residual moisture, ether extract (oil), and ash were determined according to the Official Methods of the AOAC (1).

Nitrogen was determined by the Kjeldahl method according to Official Methods of the AOAC (1). Protein was expressed as % Kjeldahl N x 6.25.

Lysine was determined on hexane-extracted ground soybean samples essentially according to the method of Tsai et al. (14). In this method.the defatted samples were enzymatically hydrolyzed with Pronase (a non-specific, proteolyic enzyme preparation from CalBiochem Corp., La Jolla, Calif.) to the individual amino acids or short peptides, the alpha-amino groups complexed with copper, and then the epsilon-amino groups of lysine were reacted with 2-chloro-3, 5-dinitropyridine. The excess 2-chloro-3, 5-dinitropyridine was extracted with ethyl acetate leaving the epsilon-DNP-lysine in the aqueous phase. Absorbance of this solution was determined at 400 nm using a Bausch and Lomb Spectronic 20 Coloimeter.

The combined value for fiber and total carbohydrates in the soybean samples were determined by adding each of the other components of proximate analyses and subtracting from 100.

RESULTS AND DISCUSSION

Growers in the United States have a large number of soybean cultivars to choose from, but only a few adopted cultivars are found in a given region because soybean varieties are photoperiod-sensitive and subject to daylength variations across the country. Soybean yields and several other plant characteristics of 12 soybean cultivars are presented in Table 1.

Table 1. Performance of soybean cultivars grown in the Lower Rio Grande Valley of Texas.

Cultivar	*Yield (bu/acre)*	*Seed Wt. (g/100 seed)*	*Plant Height (inches)*	*Test Wt. (lb/bu)*	*Moisture (%)*
Hampton-266A	36.2	16.0	16	55	11.4
Hardee	34.3	13.0	20	55	12.3
F 67-1533	24.8	11.2	24	56	13.6
Jupiter	23.9	12.9	28	57	13.7
Bragg	23.5	11.1	13	56	11.0
F 66-1166	22.8	10.3	20	56	11.2
F 65-421	22.6	15.8	23	57	12.3
F 66-1534	22.2	13.0	26	57	11.4
F 66-1537	20.7	10.4	20	56	10.9
F 55-170	17.2	13.3	40	55	13.1
Improved Pelican	15.8	8.7	30	56	10.9
F 63-4000	15.0	14.6	12	55	11.1

The two highest yielding soybean cultivars were Hampton-266A with 36.2 bu/acre and Hardee with 34.3 bu/acre. The other ten cultivars were below average yield of 25 bu/acre. Plants of Hampton-266A, F63-4000 and Bragg varieties, however, were too short, less than 20 inches, to harvest effectively with a combine. Plant heights of the cultivars ranged between 12 and 40 inches. A cultivar should be at least 20 inches tall for the combine to effectively harvest the entire crop. The taller cultivars might out-yield the shorter when machine harvested because a greater percentage of the soybeans would be harvested from larger plants. However, the taller cultivars did not out-yield the shorter ones in this study where the plants were hand harvested.

The weight of 100 seeds indicates the size of the bean. The largest soybeans were produced by Hampton-266A (16g/100 seeds) and the smallest by Improved Pelican (8.7g/100 seeds). Cultivars differed very little in test weight and moisture levels.

Results from the chemical evaluation of seven soybean cultivars are presented in Table 2. Protein levels in soybean cultivars reported in this study are within the range of those reported by Smith and Circle (13) for current soybean cultivars of the ten maturity groups. Protein levels of Hampton and Hardee varieties are reported to be 38.7 and 41.4%, respectively. In our study, Hampton-266A and Hardee had protein contents of 36.8 and 39.9%, respectively, which are slightly lower than values reported for these cultivars grown in another area. Values for other cultivars used in this study were not available in the literature. Dies (3) reported wide range of protein values from 32.4 to 50.2% for 128 cultivars.

Table 2. Analyses of soybean meal samples from seven cultivars of soybeans grown in the Lower Rio Grande Valley of Texas.[1]

Cultivar	*Residual Moisture*	*Protein (N x 6.25)*	*Oil*	*Ash*	*Carbohydrate Fiber*	*Lysine*[2]
			%			
65-170	9.4	40.5	22.6	6.4	30.5	5.9
66-1534	8.4	38.7	23.0	6.2	32.1	6.1
67-1533	10.0	37.9	24.1	6.5	31.5	6.2
Hampton-266A	8.7	36.8	25.5	6.2	31.5	6.5
Hardee	9.2	39.9	23.9	6.3	29.9	5.9
Improved Pelican	8.4	36.3	25.4	6.7	31.6	6.1
Jupiter	9.2	37.0	25.1	6.0	31.9	6.6

[1] Values in table represent an average of triplicate determinations on 2 composite samples from each cultivar, and except for residual moisture, are reported on a dry-weight basis.
[2] Lysine is reported as percent of protein (N x 6.25).

Krober and Cartter (6) and, later, Hymowitz et al. (4) have shown an inverse relationship between protein and oil levels in soybean cultivars. We also found that the cultivars with lowest protein contents had the highest oil values. Oil values for varieties in this study were slightly higher than those in the literature, possibly because hulls were partially removed during grinding. Oil contents were consistently higher than those reported elsewhere when oil was extracted with ethyl ether, petroleum ether, or hexane, both as direct and indirect determinations. Oil values in this experiment ranged from 23.6 to 25.5% while Smith and Circle (13) reported a range of 18.3 to 22.5% for soybeans from the ten maturity groups. These results indicated that soybeans grown in this area might have higher than normal oil values.

Total carbohydrates (carbohydrate plus crude fiber) ranged from 29.9 to 32.1% and were within the lower range of values reported by MacMasters et al. (7), but in the upper range or higher than those reported by O'Kelly and Gieger (9). These authors reported a range in total carbohydrates of 31.1 to 43.9% for garden-type soybeans; whereas, our cultivars were field types. However, our values were generally higher than the 17.9 to 30.2% reported by O'Kelly and Gieger (9). Total carbohydrates and oil tended to be higher in samples with lower protein levels, as noted by Cartter and Hopper (2). In our beans however, this relationship apparently depended on the higher oil content because total carbohydrates did not vary appreciably.

Ash values for soybean cultivars in this study averaged 6.3% and ranged from 6.0 to 6.7% which were slightly higher than the average of 5.0% reported by Cartter and Hopper (2) for 10 cultivars grown at different locations over a 5-year period. The colorimetric procedure of Tsai, et al., (14) for the determination of lysine provided a quick and simple method for estimating the lysine content of soybeans. Lysine values of protein are often used to indicate protein quality especially for foods which are deficient in lysine (8). In this method alpha-amino group of the lysine is complexed with copper and the epsilon-amino group reacts with 2-chloro-3, 5-dinitropyridine. The colored complex of lysine-epsilon-2-chloro-3, 5-dinitropyridine is extracted and determined colorimetrically. Reactions of various naturally occurring compounds with the epsilon-amino group renders lysine unavailable. Since these epsilon-amino groups in unavailable lysine do not react with 2-chloro-3, 5-dinitropyridine in the epsilon-amino position, determinations of lysine by this method serves as a good indicator of available lysine in the protein. The values for lysine (Table 2) are within the range of reported values for lysine in soybean protein. The average lysine content of the protein for seven varieties was 6.2% with a range from 5.9 to 6.6%. These values are slightly lower than the 6.9 g of lysine per 100 g of protein in whole soybean meal reported by Rakis et al. (11).

In conclusion, several soybean cultivars have exhibited yields, growth characteristics, and chemical composition suitable for commercial production in the Lower Rio Grande Valley Area of Texas. Growth characteristics of at least three of the shorter growing cultivars may be a limiting factor due to the difficulties of combining the short soybeans. However, yields and seed size of at least one (Hampton-266A) might offset losses due to size of the plant. Chemical composition of soybeans grown in this area compare favorably with values reported for those grown in other areas. Protein, total carbohydrates, ash, and lysine values were within the range of reported values and oil levels were slightly higher.

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Effect of Sodium Chloride Salinity on Root Reduction Capacity of Two Sorghum Varieties

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ABSTRACT

Salinity (NaCl) affected the ability of sorghum to reduce Fe^{+++} to Fe^{++} as indicated by the formation of Turnbull's blue precipitate at the reduction site and subsequently in the nutrient solution. A lowering of nutrient solution pH also indicated a differential in root reduction capacity as affected by salinity. Salinity affected the reduction capacity of the RS-671 variety less than that of the ATX-399 variety.

Specific salts or salinity affect plant growth and nutrient uptake (4, 5, 6). Known effects include increased osmotic pressure of the nutrient solution, which limits water uptake; toxicity of specific ions; and nutrient interaction (1, 3).

Plant species, varieties, and strains differ sharply in their growth response to given soil and environmental conditions. For example, one soybean variety (PI) is very susceptible to Fe chlorosis under calcareous soil conditions, while another variety (HA) is nonsusceptible or resistant (2). This difference has been attributed to the specific ion reduction capacity of the roots of the two varieties.

Therefore, roots exposed to saline environments may have a greater or lesser reduction capacity for Fe than those growing in more favorable rooting environments. The plant itself has some mechanism for maintaining a favorable ionic environment within the cell. This indicates that the plant somehow selectively accumulates ions from environments containing many nonessential ionic species.

The objective of this research was to determine if NaCl salinity affected the reduction capacity of two sorghum plant varieties, ATX-399 and RS-671.

METHODS AND MATERIALS

Salinity effects on the reduction capacities of sorghum varieties ATX-399 and RS-671 were determined by a technique developed for measuring reduction capacity of iron-efficient and inefficient soybean roots (2). This technique involved a solution color change when a blue precipitate is formed in the nutrient solution at the reduction site.

The sorghum plants tested were germinated on cotton gauze. After germination, they were transferred into ½-pint plastic boxes containing inert white sand and a soil conditioner (Perlite). The plants were watered with 1/10-strength nutrient solution (2) for 10 days. Then they were placed in 240 m. of nutrient solution and aerated. The electrical conductivities (EC's) of the nutrient solutions were adjusted to 0.3, 3, and 9 mmho/cm with NaCl.

To measure the capacity of the roots to reduce ferric (Fe^{+++}) to ferrous (Fe^{++}) iron, potassium ferricyanide (K_3 Fe $(CN)_6$) was added to the saline nutrient solution to make a 1 x 10^{-5} M solution. The brownish-yellow nutrient solutions contained 2.75 ppm Fe^{+++} as $FeCl_3$ at the beginning of the experiment. Ferricyanide reduction was determined by spectrophotometric measurements of the nutrient solution at 410 mu with a Bausch and Lomb Spectronic 20 Colorimeter. (Use of a company or product name does not imply approval or recommendation by the U.S. Department of Agriculture of the product to the exclusion of others which may also be suitable.) The pH changes of the solutions were monitored with an expanded scale Beckman Zeromatic pH meter.

RESULTS AND DISCUSSION

When $K_3 Fe(CN)_6$ was added to the saline nutrient solutions containing 2.75 ppm Fe as $FeCl_3$, hexocyanoferrate was formed in the mixture. As Fe^{+++} was reduced to Fe^{++}, the solution turned from brownish-yellow to blue. Most reduction occurred at the lowest NaCl salinity level (EC 0.3 mmho/cm) and the least reduction occurred at the highest NaCl salinity level (EC 9 mmho/cm) as indicated by visual observation of the Turnbull's blue precipitate on the primary root and root hairs. The salinity effect on reduction capacity of the plant is possibly related to salt-cytochrome interactions. The primary reduction sites were on the root hairs near the tips, since a larger amount of precipitate formed at this location than on the larger, more mature root sections. In the check solutions (aerated without plants), no color or pH changes were detected. After 18 hr, the EC 9 mmho/cm nutrient solution for the RS-671 variety remained yellow (little reduction) and had 90% transmittance, as compared with blue solutions and 96% transmittance for the two lower salt solutions.

A comparison of the relative ability of the two varieties (ATX-399 and RS-671) to reduce Fe under NaCl salinity conditions was measured by the pH change with time. Initial pH was 7.04 in all solutions. In 24 hr the pH of the solution at the medium salinity level (EC 3 mmho/cm) had decreased 0.48 pH units for the ATX-399 variety as compared with 1.14 pH units for RS-671 variety. At the highest salinity level (EC 9 mmho/cm), the difference between the varieties was less, 0.37 and 0.70 for ATX-399 and RS-671, respectively; however, the decrease in pH again was greatest in solutions containing the RS-671 variety.

As the salinity of the solution increased, the ability of the plant roots to reduce ions in the growth medium decreased. Evidently, differences exist in reduction capacity of the two sorghum varieties (ATX-399 and RS-671) under similar physiological salt stress, as previously demonstrated with other plant species (4, 5, 6).

Using plant reduction capacity in future breeding programs could have far-reaching possibilities for improved plant nutrition under adverse nutritional soil conditions, such as saline or highly calcareous soils.

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