JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 27, 1973

FRONT COVER: A Star Ruby grapefruit orchard under chemical weed control and trickle irrigation.

JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 27, 1973

Published by

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

P. O. Box 107, Weslaco, Texas 78596

Table of Contents

Table of Contents

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 6 monthly 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 27 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.

Officers of the Rio Grande Valley Horticultural Society 1973

PRESIDENT	Gilbert Ellis
PRESIDENT ELECT	Norman J. Sluis
VICE PRESIDENTS:	
Citrus	Aubrey Gates
Vegetables	Dr. Roy E. McDonald
Ornamentals	Harry Foehner
Special Fruits	Dr. Heinz Wutscher
DIRECTORS:	
Citrus	Dr. Arlen Klosterboer
Vegetables	Dr. Robert Menges
Ornamentals	Mrs. G. Browning Smith
Special Fruits	Dr. R. H. Cintron
At Large	Herbert Dean, Dr. Ben Villalon
TREASURER	Dr. Roger Albach
SECRETARY	Dr. Ben Villalon
JOURNAL COMMITTEE:	
Editor	Dr. Lavern W. Timmer
Associate Editors	Dr. Bailey Sleeth, Dr. Harold Gausman
NEWSLETTER	Dr. John Fucik

INSTITUTE PROGRAM COMMITTEE:

Dr. Roy E. McDonald, Chairman; Dr. Harold E. Brown, Dr. Joe B. Corns, Mrs. G. Browning Smith

DR. BAILEY SLEETH

Recipient of the Arthur T. Potts Award 1973

The Rio Grande Valley Horticultural Society annually presents an award named after its first recipient, Arthur T. Potts, to a person with major contributions to horticulture. The 1973 award goes to Dr. Bailey Sleeth.

Dr. Sleeth was born on November 1, 1900 in West Virginia. While working for his B.S., M.S. and Ph D. degree at the University of West Virginia he supported himself by teaching school. His graduate work on Fusarium wilt of watermelon was of horticultural interest. In 1932 he was employed by the Bureau of Plant Industry of the U. S. Department of Agriculture as a plant pathologist to work on forest diseases. During World War II he worked on diseases of guayule, a rubber-producing plant, and later did research on plant diseases in a newly developed irrigated area in Arizona. He came to the Texas A&M Research and Extension Center in 1951 where he worked as a pathologist until his retirement in 1967.

His many accomplishments have been published in 72 papers in scientific journals. Among his outstanding contributions to Rio Grande Valley horticulture were the development of an inexpensive and effective wound paint, which helped save many citrus trees after freezes, the determination of the cause and how to control *Botrytis squamosa* onion blight in the late 1950's, extensive virus work with citrus which resulted in the availability of psorosis-free budwood and a detailed knowledge of the virus status of the various citrus varieties in this area.

Dr. Sleeth is a member of 10 scientific societies. He has been a very active member of the Rio Grande Valley Horticultural Society since he came to Weslaco and served as associate editor of the Journal of the Society, as secretary-treasurer, director of the Annual Institute, president and newsletter editor. For the last two years he has been editor of the Journal and by compiling an index in last year's issue provided a very valuable service to readers. He is far from idle in his retirement, still carrying out experiments at Rio Farms, Inc., where he is agricultural advisor.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY PATRON AND SUSTAINING MEMBERSHIP, 1973

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.

PATRON MEMBERS

Bentsen Development Company, Mission
Dennisons, Weslaco
Hoblitzelle's Ranch-O-Hills, Mercedes
Interstate Fruit and Vegetable Co., Inc.,La Feria
La Casita Farms, Inc., Rio Grande City
Red Barn Chemicals, Inc., Tulsa, Ok.
Rio Farms, Inc., Monte Alto-Edcouch
Walter Baxter Seed Company, Weslaco
W. T. Ellis Company, Mission

SUSTAINING MEMBERS

The Ansul Company, Weslaco
Central Power & Light Company, San Benito
Charles A. Rogers & Sons, Inc., Donna
Crockett Groves, Inc., Harlingen
First National Bank, McAllen
First National Bank, Mercedes
First National Bank, Weslaco
FMC Corporation, Riverside Division, McAllen
FMC Corporation, Niagara Chemical Division, Los Fresnos
Griffin & Brand of McAllen, Inc., McAllen
Hidalgo County State Bank & Trust Company, Mercedes
Knapp-Sherrill Canning Company, Donna
Magic Valley Electric Coop., Inc.,Mercedes
McAllen Fruit & Vegetable Co., McAllen
McAllen State Bank, McAllen
Oaks Irrigation Manufacturing Company, Pharr
Pan American Bank, Brownsville
Stauffer Chemical Company, Weslaco
Tex-Ag Co., Inc., Mission
Texas Soil Laboratory, McAllen
Texsun Corporation, Weslaco
Tide Products, Inc., Edinburg
United Foods, Inc., Brownsville
Valley Production Credit Assoc., Harlingen

Program of the Twenty-seventh Annual Institute
Rio Grande Valley Horticultural Society
January 23, 1973

MORNING SESSION: Dr. Harold E. Brown, Chairman

Address of Welcome .... Dr. John E. Fucik, President
RGV Horticultural Society

Federal-State Market News –
The Eyes and Ears of the Industry .... John D. Engle, Officer-In-Charge, Federal-State Market News Service, Weslaco

Mechanical Harvesting and
Handling of Citrus .... Ray E. Armstrong, Associate Professor, Texas A&M University Experiment Station, Weslaco

Current Status of Citrus
Blackfly in the Rio Grande Valley .... Edgar A. Taylor, Acting Area Director, Subtropical Texas Area, USDA, ARS, Weslaco

A Bright Future for
Vegetable Marketing in Texas .... John H. Poerner, State Representative, Hondo

TexaSweet Advertising,
Does It Pay? .... J. Frank Gross, Manager, Texas Valley Citrus Committee, Pharr

Presentation of Arthur T.
Potts Award .... Dr. John E. Fucik, President
RGV Horticultural Society

AFTERNOON PROGRAM: Dr. E. E. Burns, Chairman

Nutrition Labeling .... Dr. H. Neal Dunning, Branch Chief, Food & Nutrition Resources, FDA, Washington, D. C.

Current Status of the Star Ruby .... Dr. Richard A. Hensz, Professor and Director, Texas A&I University Citrus Center, Weslaco

AFTERNOON PROGRAM (Continued)

Viral Diseases of Vegetable Crops .... Dr. Ben Villalon, Assistant Professor, Texas A&M University Experiment Station, Weslaco

Bacterial Diseases of Vegetable Crops .... Dr. Marvin E. Miller, Assistant Professor, Texas A&M University Experiment Station, Weslaco

EVENING PROGRAM: Dr. Joe B. Corns, Chairman

New Plants for Texas .... Dr. Edward L. McWilliams, Associate Professor, Texas A&M University, College Station

Personal Health and Plant Management .... Dr. Leo L. Bailey, Professor, Texas A&I University, Kingsville

A Bright Future for Vegetable Marketing in Texas

JOHN H. POERNER
State Representative, 45th Legislative District
Talk presented at the 27th Annual Institute of the
Rio Grande Valley Horticultural Society.

I assume the financial success of any product, fabricated or grown, would be in the marketing of that product at a price of sufficient amount to allow a percentage above cost of production. With this basic premise, I want you to know that your speaker was an absolute novice to the field of vegetable marketing and this was the only general guideline available to me as this Committee began its work. It might be well to also admit that I had read the newspapers in the San Antonio area and there was the hue and cry from the buying public of lettuces at the price of 9c per head in the field and 39c per head in the supermarket. The farmer contended he was losing money, and the processor said his cost of transportation and processing have doubled in the last 3 years, but he has not passed on all these costs to the brokers. The brokers never made a public statement about the matter as their names are not commonly known in the area and the retailer was saying he was entitled to a 25% mark-up after an allowance for spoilage and other factors that are common in the vegetable marketing field.

The growers in the Winter Garden district, who were at that time, in my legislative district, made many pleas that something must be changed in the field of vegetable marketing in order for them to survive. I met with members of the Texas House from the vegetable growing areas of our state to see if the problem existed statewide, or was just peculiar to my area. As is the case more than the exception, the problem did appear to be statewide and I introduced H.C.R. 129 in the 62nd Legislature to authorize a study committee to probe into the many factors and background of this topic. The resolution authorized three members of the House, three members of the Senate, two members to be appointed by the Governor and one member to be appointed by the Commissioner of Agriculture. The House immediately appointed then Representative and now your distinguished Senator, Raul Longoria, Representative Delwin Jones of Lubbock and myself. The Senate appointed Senator Snelson of Midland, Senator Beckworth of Longview, and Senator Bates of Edinburg. The Commissioner of Agriculture, Mr. John C. White, selected Mr. Eugene A. Van De Walle of San Antonio as his appointee, and the Committee's staff was comprised of Mr. Bob Gray, Assistant Marketing Director of the Department of Agriculture, and Mr. John Carter of Legislative Council. These members constituted the active appointments and from Governor Smith — I assume he felt that the Committee was not necessary even though I was never able to so much as receive an explanation from him for his refusal to make the appointments.

The Committee's first organizational meeting was held on June 21 in Austin with all Committee members present with the exception of Senator Bates. The organizational committee was devoted to plans for in-state and out-of-state hearings and adopted a budget of approximately $10,000. The cost of the Committee's operation was to be borne equally by the House and Senate budgets. The Committee hired Mrs. Linda Browder as Secretary and authorized her to write the various states involved in the production and marketing of vegetables to obtain a copy of existing marketing orders or legislation. The Committee created a Vegetable Marketing Library for retention of these items of publication for the Committee's work and also for the review of any interested citizen. We received prompt responses from all of the states contacted and usually the reply came from the Commissioner or Director of Agriculture of that state with a letter of explanation about their particular legislation in the vegetable marketing field.

Public notice was given and a public hearing was held in the Old Supreme Court Hearing Room in Austin on July 12, where the witnesses spotlighted the items of quality control and Mexico imports.

Public notice was given and a public hearing was held in the Hidalgo County Court House in Edinburg on August 30 where the Committee held its largest hearing. The Honorable John C. White, Commissioner of Agriculture of our State, was the first witness followed by leaders in the industry in the Valley area. In addition to the Committee members, we were privileged to have Representative Bud Atwood and Representative Menton Murray as active participants in the hearing.

The third and last in-state hearing was held in Uvalde where the consensus opinion of witnesses testifying before the Committee was for the need to permit the small producer to continue operation. The Edinburg and Uvalde participants also reflected the need for improved weather reporting facilities and in particular, a way of knowing the weather conditions existing in other states, especially California, during the harvest season. This was pointed out by Charles Rankin, Farm News Director of KBOR and KURV Radio Stations in Brownsville and Edinburg, respectively. He also noted that there is a need during the harvest season to have hourly weather reports from other vegetable producing states.

At the conclusion of the in-state hearings, it was quite obvious to the Committee that California was the leader in the nation and that the Committee should concentrate its efforts in reviewing that state's procedure and policy. The Committee was adequately funded to study other states and it had been previously decided that we would include Colorado and Florida in this out-of-state review. About the time the Committee completed its in-state hearings, in between special sessions of the legislature, Governor Smith decided to revise the insurance laws of our state and we were plagued with a fourth special session in two years. At this point, I might say that the members of the legislature were not paid on a full time basis and it is necessary to allow members to return home to provide a livelihood for their families and it is very difficult to ask the members to delay their private business in favor of special study committee activities following a special session of the Legislature. The $10,000 I previously mentioned as the budget for the Committee was to be used only for expenses of travel and of operating the Committee and no part of it was or could be used to pay members of the Committee for their time. So, with these various factors that deterred the fullest potential of the Committee, I want to say that we did the best with what we had available to us and concentrated on the one out-of-state meeting in California.

The members traveling to California were Representatives Longoria, Jones and myself, along with Mr. Van De Walle, Mr. Bob Gray, and Mr. John Carter. The Committee was briefed by Dr. Jed A. Adams, who had previously spent some time in Weslaco, and Mr. Vernon L. Shahbazian, Chief of the Bureau of Marketing in the Division of Marketing Services. The Director of Agriculture, Mr. C. Brunel Christensen, briefly visited with the Committee members. The three day California briefing and tour was started by conferences in Sacramento that gave us the background of California's 39 marketing orders. It is quite obvious to the members of the Committee that truly this state is the leader in this field and it certainly gives some cue that Texans should make an attempt to review the laws of this state to improve the marketing of their product. The procedure in California for instituting marketing orders has been revised from time to time to meet the immediate needs for the commodity. In the beginning, that State had no way of terminating a marketing order once it had been instituted and this created a problem. Mr. Shahbazian indicated that one of the best ways adopted by that State for removing a marketing order once instituted is if 25% of the producers regulated by number and volume or 25% of the handlers by number and volume or both of them if both are involved, can force a hearing to consider termination. I bring this up because I know at one time this state did have a marketing order on carrots. The program became a very controversial issue and placed a stigma on the idea of a marketing order being a tool to assist in this function of our industry. In privately discussing this problem with some of the people who were in the business at that time, I can still detect the many scars and hard feelings that may have existed during that period of time. The California procedure, once the hearing had been called, would be to have a vote on the issue for continuance. Also, the marketing order, when instituted, is a self-destruct matter in five years, unless a hearing was held to make determination whether the order will continue. Their law is also broad enough so that you can write a marketing order to terminate it at any predetermined time. The one peculiar aspect of the California marketing order which is probably the one that makes it a very workable issue, and incidentally, an item that the Texas carrot marketing order did not have and I find it very important as I review the procedure used by the various states is as follows: "the producers who represent 51% of the volume or 51% of the handlers who represent 51% of the volume when signed to a petition to terminate. . .you terminate." The one thing we must observe by this rule in California is that both are involved, the producer and the handler. It is a dual effort, both must be involved for successful marketing, and both have their say. This rule also prohibits one or two major producers or handlers from controlling the issue. This so-called "double-hitch", one, providing that the 51% of production must also represent 51% by number and the other one, same being true of handlers, certainly provides the check and balance that must be prevalent for the operation and stability of any markeitng order.

The briefings were followed by a visit to the State Capitol where we talked with Senator Way and Assemblyman John Brigg who are Chairmen of their respective agricultural committees of that legislative body. The remainder of the California trip was devoted to tours arranged for us by the Department of Agriculture of that state. The Committee members traveled through several valleys where they could see first hand the harvesting of several crops and visit with growers and shippers.

The final meeting of the Committee was held in Austin and adopted the following recommendations:

1. A copy of each transcript of hearing and the report of the California trip along with the Vegetable Marketing Library that has been developed be filed in the Legislative Reference Library.

2. Expand research in Texas to search for improved varieties of vegetables and improved transportation for better temperature and moisture control.

3. Enact state legislation to permit marketing orders in Texas, by category of vegetable and/or variety of vegetable. To be implemented *only* by a majority vote of growers and shippers. The State of California has adopted various formulas for determining the type of vote necessary on a particular category of vegetable, usually working through the trade organizations within the industry.

4. It is a further recommendation of this Committee that organizations involved with agriculture in Texas work closely with the 63rd Legislature in the preparation of this legislation.

5. It will be recommended that the Texas Legislature call upon legislatures in other vegetable producing states to join with them in asking Congress to act as their agent in dealing with foreign governments. This will be necessary when asking other countries to establish equal standards in sanitation and inspection of foreign produced vegetables.

6. It is the recommendation of this Committee that the 63rd Legislature allocate monies to the Texas Agricultural Extension Service to adequately educate producers, growers and shippers on a statewide marketing order program.

7. It is the final recommendation of this Committee that the study of vegetable marketing be continued through the 63rd Legislative Session and Interim period so that a full and comprehensive study of other states' programs for implementing state marketing order programs can be completed.

It is my conclusion that this phase of agriculture is in need of assistance from leadership throughout the state. I use the broad term leadership because it cannot be solely derived from your state government. The legislature can only provide the tool of a marketing order or give you the enabling legislation so that you can institute it if you want to. The true thrust of this leadership must come from growers and shippers of our state. It is your industry. . .you are the experts and we are simply elected officials with a little bit of knowledge in many fields and as the old cliché would dictate. . ."master of none." I think I speak for the agriculture committees of both the House and Senate in this new session in that we will probably concur with anything that the majority of you will ask us to pass.

I guess it is more appropriate to sum it up to say that we have gained knowledge. We know that we are not "NUMBER ONE" in the nation in our procedure. The industry does need some new laws to give them the authority to govern themselves in their procedure in marketing. It will be in the best interest of the buying public and the consumer if these procedures were instituted. It is going to improve the economy of our state if we have a procedure that will provide stability in prices in markets and if we can assist the industry in additional appropriations for research and weather reporting connections and facilities with other states where a change of weather may immediately affect the price of our produce.

THANK YOU for asking me to be a part of your conference and I hope you will give some time to reviewing the library created by the Committee that is on file in your State Capitol.

TexaSweet Advertising, Does It Pay?

Frank Gross
Manager, Texas Valley Citrus Committee
Talk presented at the 27th Annual Institute of the
Rio Grande Valley Horticultural Society.

Dr. Max Brunk, Protessor of Marketing, Department of Agricultural Economics, Cornell University, Ithaca, New York, and his associates, have researched the subject for the past several years by means of actual tests and personal interviews with thousands of housewives. He states that advertising does pay.

The total U. S. advertising bill for 1971 was $20,600,000,000. Twenty-two billion five hundred and twenty million dollars is estimated for 1972. This includes advertising everything from soups to nuts. The five leaders advertising as per cent of sales are:

Number one advertiser was Proctor and Gamble, spending $275,000,000., 7.8% of sales;

Number two was Sears, Roebuck & Company, $200,000,000., 2% of sale;

Third ranking advertiser was General Foods Corporation, $160,000,000., 7.8% of sales;

Number four was General Motors, $140,377,000., 4% of sales; and

Number five was Warners-Lambert Pharmaceuticals, $128,000,000., 15.1% of sales.

The highest percentage of sales spent for advertising was in the drugs and cosmetic industries. Many of these spent from 15% to as high as 32% of their total sales in advertising. I don't believe it possible that these people would be spending this amount of money for advertising if it did not pay.

Now, to say if you advertise you are automatically going to be successful, would be in error because a number of things have to be considered when you determine *HOW* you advertise. Each segment of our economy has different problems and different advantages. For example, a manufacturing firm can control, to a certain degree, the quantity produced. They can, also, control the quality of their product. In the fresh fruit industry, individual sales organizations can control the quantity they market. However, the industry as a whole, in a free society, cannot control the quality, so it is from this position that the Texas Valley

Citrus Committee is operating. We do not grow the fruit; we do not harvest the fruit; we do not pack or sell the fruit. However, we are charged with the responsibility of trying to promote Texas fruit in competition with other producing areas in the United States as well as foreign countries whose fruit is imported and marketed in competition with ours.

The Texas citrus industry, comparatively speaking, has had a very limited and brief experience in promotion and advertising. The first effort was made in 1959 and was impeded by the freeze in 1962 and curtailed somewhat by Hurricane Beulah in 1967. However, I can assure you we have come a long way and we have made some long strides in promoting Texas citrus. We have learned, and are still learning, some important lessons in methods to be used to promote our citrus.

Let us review for a moment some of the terms used in the efforts to promote sales of Texas citrus. One of the terms used is advertising.

ADVERTISING. Advertising is defined as any paid form of nonpersonal presentation and promotion of ideas, goods, or services by an identified sponsor. This ranges from newspapers, radio, and TV, to skywriting, point-of-purchase posters, and blotters.

PUBLICIZING. This involves preparing and disseminating news items about a product or service. This may relate to the way a product is made or produced, to its characteristics and attributes, to the way it can be used, and to other similar aspects.

MERCHANDISING. In the promotional field, keeping salesmen and dealers enthusiastic about selling a product or service is called merchandising. Typically, merchandising efforts are directed at the retail segment of the trade, but they may also be directed at brokers, wholesalers, and similar distributive factors. By its very nature, merchandising calls for direct personal contacts. Usually, dealer service representatives who have had the experience in the distributive trade, who know the trade's problems, and who can speak the trade's language, are engaged for this work.

PUBLIC RELATIONS. Most product promotion programs require the active assistance and cooperation of the trade; for example, media, food specialists, and similarly allied interests, and public relations activities are instrumental in bringing this about. Giving luncheons and banquets for trade and media principals, participate in and supporting trade conventions, contributing materials and conducting demonstrations of an educational nature at fairs and exhibitions, and escorting home economists and demonstration agents on tours of production areas and processing plants are among the "PR" activities that can be employed by the agriculture industry groups for their product promotion.

PRODUCTION AND BRAND PROMOTION. There is a basic difference between the two. Product promotion seeks to stimulate primary demand for a product – to enlarge the market for one product in competition with similar products. Brand promotion, on the other hand, seeks to stimulate selective demand for a brand of a product – to enlarge the brand's share of the market in competition with other brands of the same product. Thus, product promotion is aimed at enlarging the total market for the product and brand promotion is aimed at increasing only the brand's share of the existing market. Brand promotion may, but does not necessarily, seek to increase total demand for a product.

PRODUCT APPRAISAL. Another important factor in advertising and promotion is to appraise the product. To begin with, you have to have a promotable product. If so, then promotion can speed up the rate of buying, but it cannot "make a silk purse out of a sow's ear," nor can it "fool all the people all the time." To promote a product which is defective in any noticeable degree is to call attention to the defect and the results can be disastrous. To promote a product, it must be right. It must fulfill the desires it was bought to satisfy and be usable in the manner people want to use it. Horeover, the product must be right whenever and wherever it is promoted. If the quality varies widely during the season, the product should not be promoted when it is substandard or poor. To be right for promotion, the product should be identifiable with the promotion. Unless a potential buyer is able to recognize the product as the one promoted, he is apt to buy a competitive product instead. There are many other factors involved, such as, packaging and price, appraisal, distributive problems, and so forth.

ESTABLISHING OBJECTIVES. Longfellow said, "I shot an arrow into the air. It fell to earth, I know not where." What happened to Longfellow's arrow should not happen to a promotional program. So one of the first things needed is to establish an objective.

PROMOTIONAL TIMING AND COVERAGE. The where and when of the marketing problems and opportunities determine the where and when of promotion. If the objectives for a program are clearly conceived, the problem of where and when to promote is already solved. Either the needs and opportunities to promote exist at a time and place or over a period and area, or they simply do not exist. Some objectives take longer to accomplish than others, depending on the nature of the tasks involved.

Some call for immediate action, and what must be done must be done quickly. Others call for market building and do not require emergency action.

PLANNING. Both marketing knowledge and promotional know-how are needed in program planning.

METHOD SELECTION. Promotional know-how is needed in method selection, not only to decide upon the method best suited for a particular task, but also upon the optimum combination of methods that are needed to attain the total objective.

MEDIA SELECTION. Most people outside the promotional field are unaware of the intense and continuing study which underlies intelligent media selection. Many seem to think the profession is one for intuitive judgement based upon personal observation and preference. Media are numerous and varied. The list extends from newspapers; radio and TV, to skywriting, shopping bags, and memo pads. Selection needs to relate the medium of the product. Consideration should include reference to the nature of the product, (Is it perishable?); the nature of the message, (Does it require color?); the distribution of the product, (Where is it sold?); the users or non-users, (What is their income status?, race?, color?, sex?,) the media, (What coverage?, circulation, etc.).

I trust I have given you some indication of the problems and the many things required in order to be competitive in a free society.

Personal Health and Plant Management

LEO L. BAILEY
Professor of Horticulture, Texas A&I University, Kingsville, TX 78363
Talk presented at the 27th Annual Institute of the
Rio Grande Valley Horticultural Society.

It is my purpose to point out to you that the growth and management of plants about the home or in one's work helps to keep the individual physically and mentally healthy. The relationship between plants and animals, between human life and animal life, between human life and plant life is very close. Human life, animal life and plant life are closely related and interdependent.

Our forefathers worked closely with their environment and often encountered difficulty in competition with nature. Early man worshipped his Gods through what is known today as Nature Religions. Even today the Hindu religion of India, Pakistan, etc. places major emphasis on animal life and some sects idolize certain animals. Buddhism, Taoism and other oriental religions emphasize man's relationship to plants.

While the Christian world emphasizes man's relationship to man, we Christians are fully aware that the person who is healthy in mind, body and spirit has a close relationship with his environment. The rural areas of the United States continue to produce men and women with the greatest mental and physical ability.

The poorest adjusted persons in our world today are those who grew up in crowded city slums where plant life and animal life are practically non-existent. In these slums rats and lice made up the animal life while weeds constitute the plant life. They know little of nature having never gone fishing or hunting and never having seen a new born calf or a baby chick. They have never planted a seed and nurtured the plant to harvest. It is no wonder these individuals do not know who they are or what their purpose in life should be.

It is not possible for all people to return to the farms and rural areas. Quite the contrary, more people are moving to the urban centers each year. It is likewise, impossible to bring the country into the city. Wise leaders are planning spacious building lots, wide streets and neighborhood parks. Areas of virgin land are being preserved in or near large urban centers. These native spots provide opportunities for city people to get out in the natural environment, to view plant and animal life, to enjoy both horizontal and vertical space.

Plant management is both an art and a science. As an art it has been slow to develop. Its beginning is hidden in obscurity. Other arts are more fully developed. Landscape Art as a part of plant management is now in the process of rapid development. More leisure time, more travel and improved living standards in the United States have contributed to this development.

As the art of plant management grows, what changes may we expect. What will it do for the nation? What will it do for the people?

It will bring about a different feeling with regard to natural and man-made beauty. As we have developed this country our main goal has been to conquer the frontier, to make money, to gain materially. We have too often explotied our human and natural resources. Our tendency has been to insist on the "practical." Enterprises not practical have been deemed as foolish, wasteful and even effeminate. Only recently have we come to realize that it is the beautiful around us what makes life worth living.

The care required to manage plants requires a certain amount of physical exercise. This exercise comes regularly and usually requires exposure to the sun and other climate elements. This tends to keep the heart and other body organs functioning properly and life is lengthened.

While we inhale oxygen and exhale carbon dioxide, the plants takes in carbon dioxide and gives off oxygen. Plants and man complement each other as each depends upon the other for survival. Plants in and around your home assure you an adequate supply of oxygen and prevent an accumulation of carbon dioxide which is toxic to man.

The challenges presented by plants help to keep one mentally alert. Plants are a constant reminder of the Creator and our close association with nature. Plants teach patience and understanding. They provide failures and successes. They provide time and reason for meditation and wonder. All these things enable the individual to have a healthy mind and spirit.

Men and women hurry through life trying to make money or trying to attain fame but they never become completely satisfied until they settle down to simple living — growing fruits, vegetables and flowers in their home garden.

RESEARCH REPORTS

Mechanized Citrus Harvesting

RAY E. ARMSTRONG, W. H. ALDRED and A. V. SHULL

Assoc. Prof., Texas A&M Univ. Agr. Res. and Ext. Center at Weslaco, TX 78596; Asst. Prof., Agr. Eng. Dept., Texas A&M Univ., College Station, TX 77843; and Citrus Production Manager, Rio Farms, Inc., Monte Alto, TX 78538

ABSTRACT

Research was conducted to determine if mechanical harvesting of early oranges and grapefruit for processing was feasible in the Rio Grande Valley of Texas. Objectives of the research included the design and development of equipment for mechanically removing the fruit from the trees, windrowing the fruit and loading it into an orchard transport. Cycloheximide was used as an abscissioning agent and tests were made to determine the optimum time after application for removing the fruit by mechanical and air blast shakers. The detached fruit was mechanically windrowed and loaded into a trailer.

Texas produces over 600,000 tons of citrus annually (1) requiring an estimated 2.4 million man hours of labor for picking. Oranges represent about 45% of this production or about 270,000 tons. Texas citrus growers received $12 - $13 a ton for oranges during the 1970-71 season (4) with a picking and hauling cost of $9 - $12/ton. This condition presented an increased need for reducing citrus harvesting costs.

A mass-removal harvesting method appeared most applicable because 65% of the oranges are processed for juice. Research by Hedden and Coppock (2) on a mass-removal harvesting system, indicated losses of less than 1% on all varieties except Valencia oranges. This study reported that the reduction was probably the result of splits in fruit caused by falling from the tree. Trees where the citrus was removed with an air blast shaker showed a reduction in yield of 5 and 12% the following year for Marsh grapefruit and Valencia oranges respectively and an increase in yield of 11% for Pineapple oranges when compared to hand picked check trees (5).

Jutras and Coppock (3) reported 90 - 95.6% removal of oranges and grapefruit by air blast shaking. Velocities of 9,500 to 10,000 ft/min were used with 50 to 80 air vane oscillations per minute.

Research was undertaken to determine if mechanical harvesting of early oranges and grapefruit for processing was feasible in Texas. Objectives included designing and developing equipment to: 1) mechanically remove citrus from the trees, and 2) collect and load the fruit into an orchard transport unit.

MATERIALS AND METHODS

The harvesting procedure chosen required a smooth and clean soil surface for sweeping and collecting the fruit and the removal of trash and spoiled fruit prior to harvesting. An "under-the-tree" cultivator was used for loosening the soil. The soil was smoothed by a modified rear mounted three-point hitch blade with a three-foot extension on the right end. The soil was smoothed with two passes. The first pass moved loose soil under the trees, and the second removed the excess soil from under the trees and provided a smooth surface from the centerline of the tree rows to the drive area between the tree rows.

Cycloheximide, an abscission agent, was sprayed on the trees by a conventional orchard sprayer. The product used was Acti-Aid (Upjohn Company, Kalamazoo, Michigan) and contained 4.22% cycloheximide. (Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the Texas Agricultural Experiment Station and does not imply its approval to the exclusion of other products that may also be suitable.) It was mixed at a rate of 1 quart with 1½ quarts of surfactant in 500 gal of water and applied to 100 trees.

A sweeping unit removed fallen fruit, broken limbs and other debris from under the trees to facilitate its collection for disposal. The sweeper utilizes a rubber finger auger for windrowing the material.

The auger (Fig. 1) has a 4-inch diameter steel tube core with rubber fingers positioned in a double spiral pattern spaced at 1.62-inch intervals with a pitch of 14.62 inches. The formed rubber fingers were 6 inches long with diameter of 0.75 inch at outer end and 1.12 inches at inner end. The auger sweeper unit was front mounted on a self-propelled 3-wheeled power unit and rotated at 300 rpm. This unit was later used for windrowing the fruit.

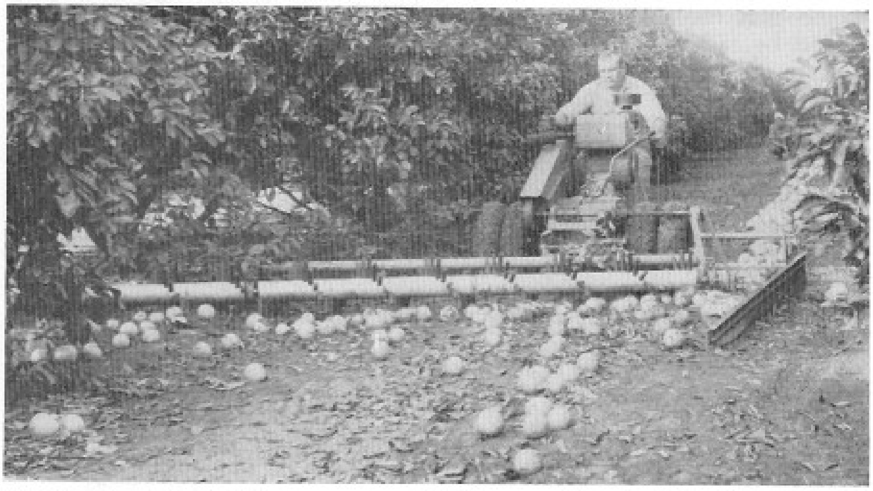


Fig. 1. Experimental citrus sweeper, used for s w e e p i n g both the debris for pick-up for disposal and for windrowing harvested f r u i t for loading into an orchard transport.

The debris was collected from the w i n d r o w by an experimental pick up unit (Fig. 2). This unit was rear mounted on a three-point hitch tractor and driven hydraulically. It contained a rotating drum 36 inches long and 15 inches in diameter with 3 rows of 5-inch long rubber fingers mounted on a 5-inch diameter core. The drum swept the material rearward onto an inclined flat wire belt with 2.5-inch metal flights which elevated the material into a container for disposal.

The force required to detach an individual fruit from the tree was measured prior to the application of the abscission agent. The pull on the fruit was made in line with and parallel to the center line of the stem and measured with a force indicator. The average force required to pull the fruit before application of the abscission agent was 16 lb. Harvesting was started when the force required to remove the fruit averaged 6 lb. or less.

Fruit was removed by shaking the trees with an inertia trunk-shaker and an air blast. The inertia shaker was a Bowie Model 6500 (Bowie Industries Inc., Bowie, Texas), rear mounted on a tractor three-point lift. It produced vibrations in one direction and in one plane. The shaker was attached low on the tree trunk, approximately 8 to 12 inches above the soil surface because of low lateral limbs. The shaking was of two intervals, approximately 5 and 4 sec duration.

Three air sources were used to remove citrus by the air blast shaking method. One source was a FMC John Bean M o d e l 577C Speed Sprayer (FMC John Bean Div., Jonesboro, Ark.) modified by closing the air discharge openings on one side forcing the full fan output through openings on opposite side. The horizontal louvers in the discharge outlet operated in their normal position and range. The fan was driven by

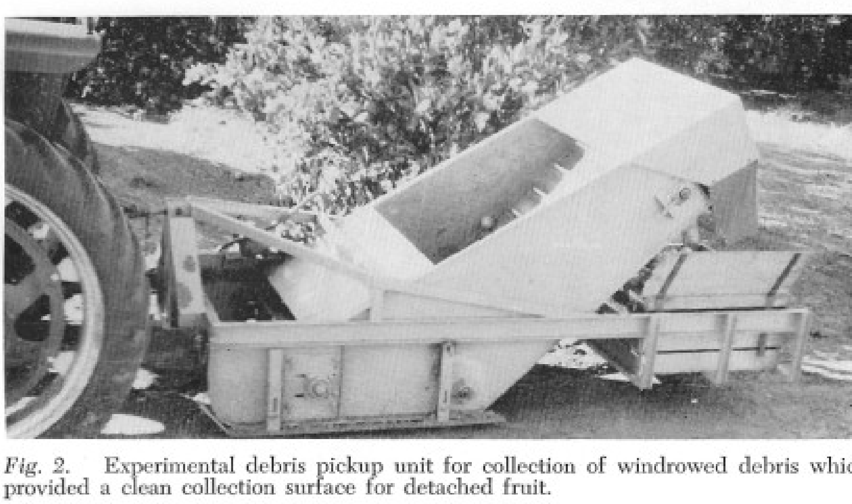


Fig. 2. Experimental debris pickup unit for collection of windrowed debris which provided a clean collection surface for detached fruit.

a Detroit Diesel Model 453 (Detroit Diesel Engine Div., GMC, Detroit, Michigan) engine and operated at 2450 rpm.

A Lockwood-Hardie Speed Sprayer (Lockwood Grader Corp., Gering, Nebraska) was also used. It was also modified by closing the air discharge openings on one side forcing the full fan output through the openings on the opposite side. The horizontal louvers in the discharge outlet operated in their normal position and range. The fan was driven by a Detroit Diesel 471 model engine operating at 1900 rpm.

The third air blast source used was an experimental blower (Fig. 3). It included three vertically stacked 26-inch diameter axial flow fans mounted on the front of an International Harvester 544 (International Harvester Co., Chicago, Illinois) tractor and driven from the crank shaft. Vertical and horizontal louvers in the discharge duct were individually manually operated to provide varied air stream directions. The fans were operated at 4300 rpm delivering a total of 58,000 CFM of air.

Fig. 3. Experimental air blast tree shaker with manually operated vertical and louvers in air discharge outlet.

The fallen fruit was windrowed by a sweeper (Fig. 1) and picked up by an experimental loader mounted on an International Harvester 656 high clearance tractor (Fig. 4). The pick up unit of the loader was mounted underneath the tractor and contained an 8-ft section of steel draper chain 29 inches wide, 0.438 inches diameter and a pitch of 1.56 inches in a two dodged down and one dodged up pattern. The draper chain velocity was twice the ground speed of the blower. A rotating drum 28 inches long with a 12-inch diameter core was mounted on the front of the main frame. The drum had 24 rows of flaps with 14 flaps per row. The flaps were four-ply rubber belting, 2 inches wide and 8 inches long which gave the drum an effective diameter of 28 inches. The peripheral velocity of the rotating drum was 2 mph or four times the 0.5 mph loader ground speed. The flaps provided constant pressure on the windrowed fruit holding it against the front and lower end of the draper chain thus aiding in lifting the citrus up onto the draper chain. The pockets in the chain held the fruit while it was elevated.

A 5-inch diameter rubber toothed roller was mounted diagonally near the rear of and approximately 1 inch above the draper chain. The roller swept the citrus laterally off the draper chain into the discharge elevator. The clearance between the roller and the draper chain permitted sweeping the fruit from the chain while allowing trash, small limbs, broken fruit and other debris to pass under the roller and off the rear of the draper chain onto the soil.

The discharge elevator was mounted on the side of the tractor. It included a frame 11-ft long containing a 12-inch wide rubber belt with 3-inch flights on 10-inch spacings. It discharged the cleaned fruit into an orchard transport. The components of the pick up unit were each

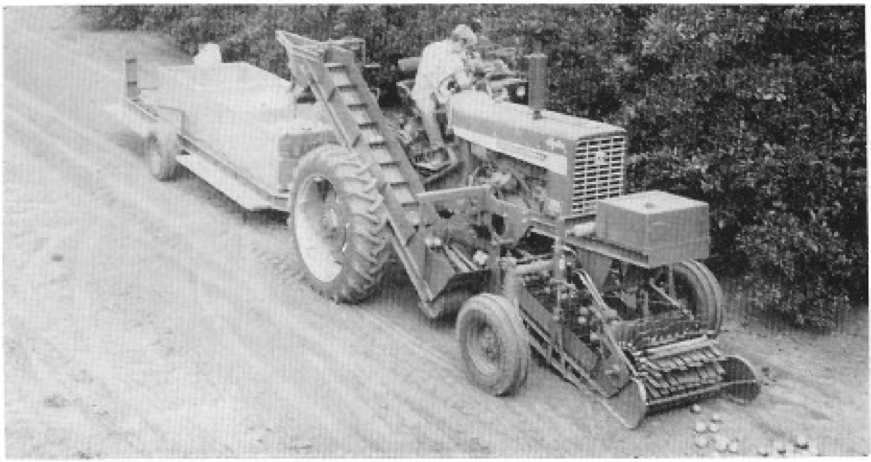


Fig. 4. Experimental citrus loader for loading windrowed fruit into orchard transport.

hydraulically driven. The pump for the self-contained hydraulic system was driven by the tractor PTO.

TEST PROCEDURE

The tests were conducted at Rio Farms, Inc., at Monte Alto, Texas, on January 21 to 25, 1972. The grapefruit were the Ruby Red variety and were planted on a 25 x 15-ft spacing. The oranges were the Marrs variety and spaced 22 x 19-ft. The average height of the trees was 12-ft for oranges and 13-ft. for the grapefruit. Approximately 50% of the trees did not have normal trunks because they had been frozen back in 1962 and had low lateral limb placement.

Four methods of fruit removal were tested: a) Bowie mechanical shaker, b) experimental air blast machine, c) modified Hardie sprayer, d) a modified FMC John Bean 577 sprayer. Plots containing four trees each were used and each treatment was replicated four times for both oranges and grapefruit.

The force required to remove fruit was measured on one tree per replication on the day the abscission agent was applied and daily there-thereafter until harvested. Harvesting was started when the force required to remove the fruit was less than 6 lb. Fruit which fell after the application of the abscission agent were collected and counted daily in all plots.

Efficiency of fruit removal was determined by dividing the sum of free fallen fruit plus fruit removed by shaking by the total fruit produced by the tree.

RESULTS AND DISCUSSION

The inertia shaker removed up to 94% of the oranges and 71% of the grapefruit after application of the abscission agent. Without the abscission agent, the inertia shaker removed up to 55% of the oranges and 37% of the grapefruit. The percent grapefruit removed was low because the plots had been accidentally ring picked prior to our tests. The ring picking removed 28% of the mature fruit.

The air blast shakers did not provide as effectual vibrations, as the inertia shaker, therefore, it was not as effective and the removal of fruit was lower. The effectiveness of the inertia shaker over air blast shakers is evident on the check trees (Table 1 and 2) where in oranges a reduction from 55% fruit removed by inertia shaking to 3% removed by air blast shaking and in grapefruit a reduction from 37% to 5%, respectively. The performance of the air blast shakers was consistent in both oranges and grapefruit. The prototype blower removed more fruit in the oranges than the Hardie and FMC John Bean 577 sprayer because of the nearly vertical side wall of the trees that permitted better placement of the air blast from the vertical air duct outlet.

Table 1. Marrs oranges removed after application of abscission agent.

Method of Removing Oranges	*Free Fall* %	*Shaking* %	*Total* %	*Control*[1] %
Bowie Shaker	19	75	94	55
Prototype Blower	13	50	63	2
Hardie Sprayer	13	33	46	1.5
FMC Sprayer	13	36	49	3

[1] No abscission spray applied.

Table 2. Ruby Red grapefruit removed after application of abscission agent[1].

Method of Removing Grapefruit	*Free Fall* %	*Shaking* %	*Total* %	*Control*[2] %
Bowie Shaker	30	41	71	37
Prototype Blower	24	39	63	5
Hardie Sprayer	26	29	55	2
FMC Sprayer	40	27	67	5

[1] Grove was ring picked by accident before test.
[2] No abscission agent applied.

The effect of the abscission material is shown in Fig. 5. The lower force required to remove oranges on 21 Jan 72 probably indicates that the oranges were more mature than the grapefruit. In normal years, Marrs oranges reach maturity in mid-December and Ruby Red grapefruit in mid-January.

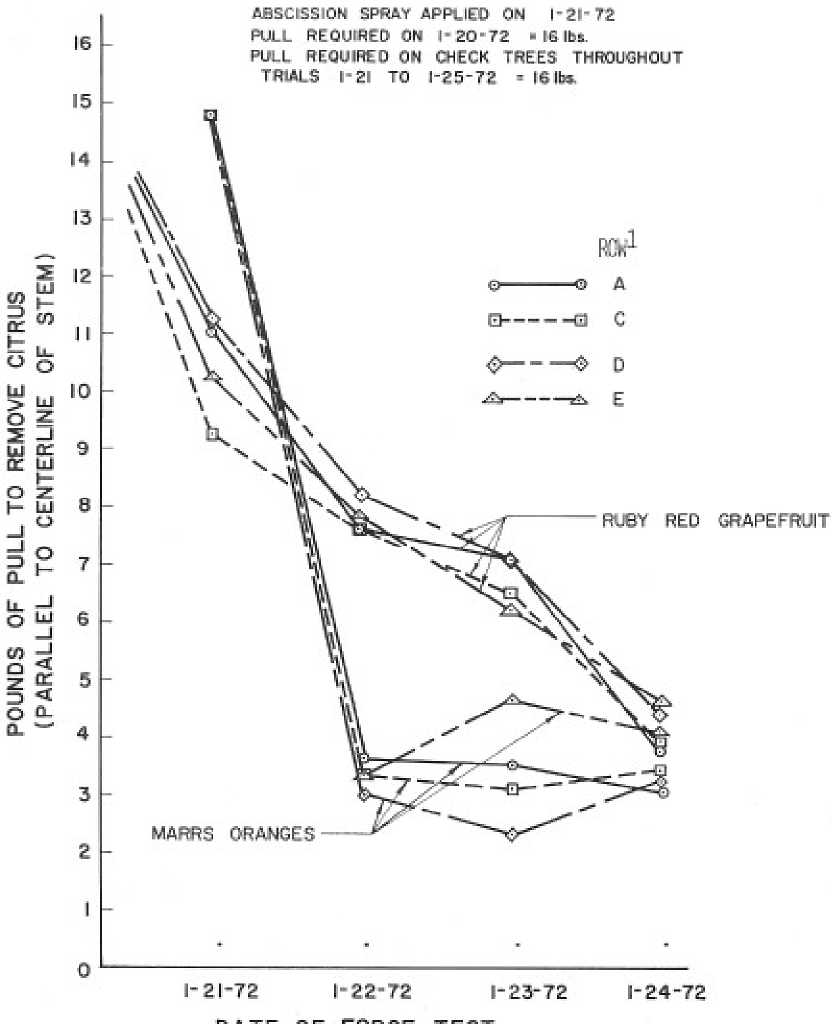
Windrowing efficiencies in replicated tests with the rubber fingers in a single spiral pattern spaced at 1.62 inches with a pitch of 14.62 inches varied from 97 to 60% with an average of 85%. The double spiral pattern of fingers provided improved sweeping efficiency. The efficiency of the sweeper can be improved from increased smoothness of the soil surface and skirt pruning of the citrus trees.

The results of this research indicate that mass-removal citrus harvesting is achievable on low silhouette citrus trees in the Rio Grande Valley. Inertia type tree shakers warrant further research for increased fruit removal efficiency. Different points of tree attachment should be studied, especially for abnormally shaped trees due to freeze damage.

Only one abscission material was studied but the increased demand for processed citrus products encourages studies of other possible abscission materials.

ACKNOWLEDGEMENTS

The authors wish to acknowledge and thank Rio Farms of Monte Alto, Texas, for their excellent cooperation in conducting this study in their citrus groves and for the use of their equipment, facilities and labor. Also, acknowledgements are due the Lake Delta Citrus Associa-



1 EACH ROW SHOWS AVE. FORCE OF FOUR REPLICATIONS.

Fig. 5 Force required to remove fruit.

tion, H&B Iron Works of Weslaco, Texas, and Jimmy Hill, Inc., of McAllen, Texas, for providing equipment.

LITERATURE CITED

1. Crop Production, U. S. Dept. Agr., Stat. Reporting Serv., Crop Reporting Board, Crop Production, February 9, 1972, p. 7.

2. Hedden, S. L. and G. E. Coppock. 1968. Effect of tree shaker harvest system on subsequent citrus yields. Proc. Fla. State Hort. Soc. 81:48-52.

3. Jutras, P. J. and G. E. Coppock. 1963. Harvesting citrus fruit with an oscillating air blast. Trans. Amer. Soc. Agr. Eng. 6:192-194.

4. Texas Citrus Mutual Newsletter. January 15, 1971.

5. Whitney, J. D. 1968. Citrus fruit removal with an air harvester concept. Proc. Fla. State Hort. Soc. 80:43-48.

Interrelationship of Root and Shoot Growth and Seasonal Growth Pattern of Citrus Seedlings

HEINZ K. WUTSCHER
Horticulturist, Subtropical Texas Area, Southern Region,
ARS, USDA, Weslaco, TX 78596

ABSTRACT

Sour orange seedlings in a growth chamber (60 F day/40 F night) initiated top growth both with unheated, nongrowing root systems and with heated (80 F), growing roots during a 90-day test. With 82 F day/72 F night, both roots and shoots grew vigorously with soil temperatures of 75 to 80 F; when the soil temperature was kept at 50 F no root growth took place and some weak shoots grew from the tops. A 3-year study of root and shoot growth of seedlings growing in pots outdoors showed a pronounced shoot growth peak in the spring, with root growth throughout the year and a weak peak in the fall. A new method was used to measure root growth.

Citrus roots are difficult to study and much less is known about them than about the aboveground part of the trees. Schneider (5) reviewed the older literature and found contradictory reports, some stating that roots and shoots grew in alternate cycles, with shoot growth occurring first, others that root and shoot growth overlapped, or that root growth preceded shoot growth. In his own work he found that root and shoot growth periods overlapped, and that root growth could take place before shoot growth. It was difficult, however, to get good estimates of root growth over extended periods of time because of the method used, which was glass panes set against the wall of a trench, through which white root tips could be counted.

By using a technique based on a method used by Heinicke (3), which permits quantitative estimation of root growth, and by manipulating root and shoot temperatures, the present study was designed to show whether root growth is necessary to trigger shoot growth.

The purpose of a parallel, long-term experiment conducted outdoors was to show the periodicity of root and shoot growth under South Texas climatic conditions.

MATERIALS AND METHODS

Seedlings of sour orange, *Citrus aurantium* L., were grown in a lath house in fine sand in 6-inch pots until they were 12 to 18 months old, and their root systems completely filled the space available. They were then removed from the pots and their root systems inserted into 1-inch mesh wire baskets of exactly the same size as the pots. Any protruding roots were cut off and the baskets placed in glazed crocks, 8 inches in diameter and 10 inches deep. The space around and below

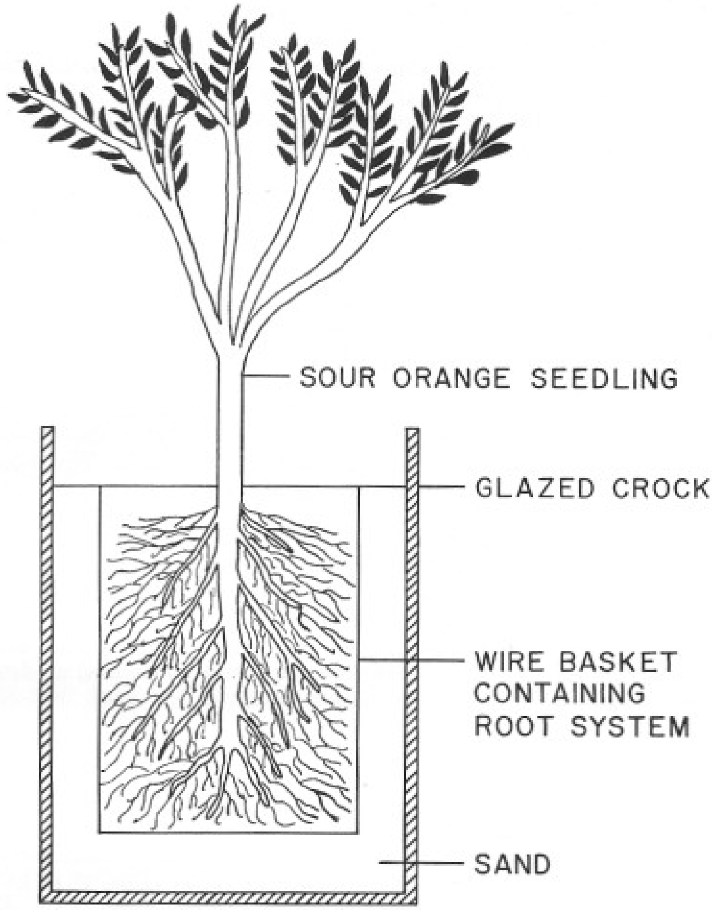


Fig. 1. Sour orange seedling with root system in 1-inch wire mesh basket planted in large crock. Root growth protruding from wire basket can be cut off after test and weighed and gives a measure of root growth.

the wire baskets was filled with sand (Fig. 1). The shoot tips were marked with pieces of string so that new growth could be distinguished later.

In Experiment I, in a growth chamber, four crocks with heating cables coiled around them were buried in 28 x 28 x 18-inch wooden boxes filled with soil. Four other trees were left unheated on the chamber floor as controls. The lighting in the chamber was provided by flourescent tubes (70%) and incandescent lamps (30%), with 14 hr of light and 10 hr of darkness per day. The temperature regime was 60 F day and 40 F night. The soil temperature in the heated pots was 80 ±2 F;

in the unheated pots it fluctuated from 40 F to 51 F. The trees were irrigated twice weekly, once with ½-strength Hoagland solution and once with rainwater. After 90 days new top growth and roots protruding from the wire baskets were cut off, dried for 72 hr in a 172 F draft oven, and weighed. The weight of roots and shoots collected is called "root growth" and "shoot growth" in Table 1.

Conditions for Experiment II were identical, except that the air temperature was 82 F day/72 F night and that the crocks buried in the soil-filled boxes were surrounded with coils of plastic hose through which chilled water (48 F) was circulated. This kept the root temperature at 50 ±2 F. To maintain this temperature the boxes were covered with 4-inch thick styrofoam plates with holes for the trees, thermocouples, and 0.045 inch I.D. tubing used to feed 1/10-strength Hoagland solution into the pots. The controls, too, were monitored with thermocouples and watered by trickle irrigation with dilute nutrient solution. Soil temperature in these pots fluctuated from 75 to 81 F. After the 90-day test period, new growth was measured as in Experiment I. The t-test was used to analyze the growth data statistically (6).

An outdoor study was made by growing 10 trees at a time in crocks as described above for 3-month periods between November 1967 and December 1971. These pots were buried flush with the soil surface in open land. A layer of gravel under them allowed drainage. The trees were watered once a week with ½-strength Hoagland solution and with rainwater as needed. Root and shoot growth were measured as described for Experiment I. A new set of trees was used for each 3-month test period.

Table 1. Shoot and root growth of sour orange seedlings over 90-day periods under controlled temperature conditions.

	Temperature regime	*Dry wt in g/tree*[z] *Shoot*	*Root*
Experiment I.	Air 60 F day/40 F night Soil 40 - 51 F	0.33	0.00
	Air 60 F day/40 F night Soil 80 F	0.63	0.75
	Probability	0.16	0.05
Experiment II.	Air 82 F day/72 F night Soil 75 - 81 F	42.74	3.42
	Air 82 F day/72 F night Soil 50 F	4.21	0.00
	Probability	0.01	0.01

[z]Each value is based on the average of 4 individual determinations.

A mercury thermometer inserted 4 inches deep into one of the pots was read at 8 AM and 5 PM on working days. These temperatures were compared with air temperatures recorded at a National Weather Service Station 1,000 ft from the site. The two sets of temperatures were very similar, with the mean daily temperatures in the pots about 1 F higher in the winter and 2-3 F higher in the summer. The 3-year averages of the monthly mean air temperatures at the Weather Station are shown in Fig. 2.

RESULTS AND DISCUSSION

The method used to measure root-growth activity offers advantages over glass panes set in trenches (4, 5). It is more quantitative and takes into account root growth all around the tree. Although the absolute amount of new roots formed during a given period cannot be determined,

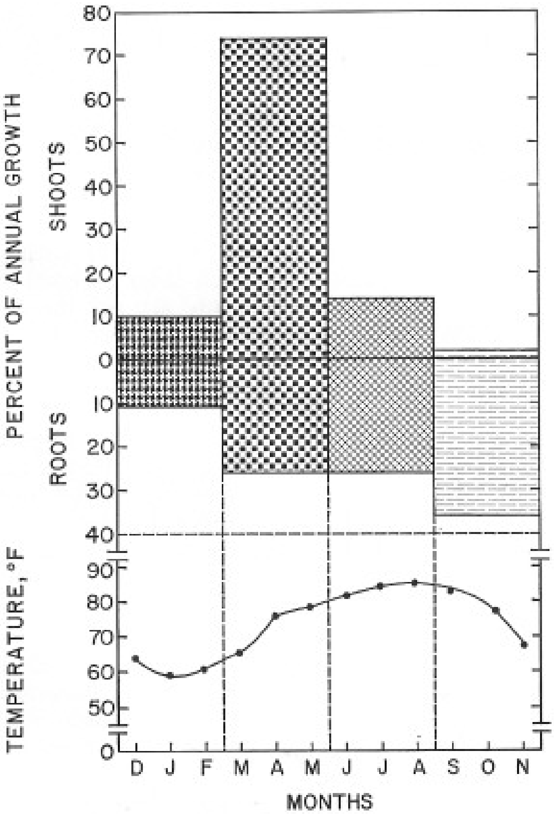


Fig. 2. Three-year means of air temperature and periodicity of root and shoot growth of sour orange seedlings in outdoor test at Weslaco Texas A & M Research and Extension Center.

because growth within the baskets is not taken into account, the fraction of the roots cut off on the outside gives a reliable measure of root-growth activity. Using wire baskets offers the possibility of unrestricted watering of the plants, which could not be done when soil cylinders containing the root system were surrounded with sand (3).

Table 1 shows that shoot growth can be initiated when root growth is prevented by low soil temperatures. Subsequent development of these shoots was severely retarded, however. Although this inhibition of further shoot development after the initial formation of small shoots with low temperature in the root sphere was apparent even under the 60/40 F temperature regime, it was particularly striking with 82/72 F conditions. There the trees having favorable growing conditions in both the root and shoot sphere grew luxuriously, while those with root growth inhibited by low temperature produced only a few small, severely chlorotic leaves.

The 3-year means of seasonal root and shoot growth of seedlings exposed to normal South Texas climatic conditions (Fig. 2) show that the bulk of the shoot growth occurred in the spring, with a minimum in the fall. Root growth took place throughout the year, even in the winter with mean temperatures close to 60 F. The greatest amount of roots was produced in the fall, coincident with the shoot-growth minimum, but this peak was much less prononnced than the spring shoot-growth peak.

The periodicity of root and shoot growth was apparently typical for the South Texas area. The results of the study agree with earlier reports based on short observation periods of much older orchard trees (1, 2, 4). Temperature, moisture, and nutrient supply are not the sole controlling factors influencing the timing of root growth. Comparing the temperature curve in Fig. 2 with growth activity shows that a given temperature cannot be used to predict a growth response, except for a general growth reduction at low temperatures. Water and nutrients were never limiting in the present experiment. The behavior of the trees in the growth chamber experiments indicates that shoot-growth flushes can be initiated without previous or concurrent root growth. Under normal climatic conditions, with nutrient status and weather favoring growth, root and shoot-growth flushes apparently occur independently.

LITERATURE CITED

1. Cooper, W. C. 1957. Periodicity of growth and dormancy in citrus — a review with some observations of conditions in the Lower Rio Grande Valley of Texas. J. Rio Grande Valley Hort. Soc. 11:3-10.

2. Cooper, W. C. and A. Peynado. 1959. Winter temperatures of 3 citrus areas as related to dormancy and freeze injury of citrus trees. J. Amer. Soc. Hort. Sci. 74:333-347.

3. Heinicke, A. J. 1936. Root growth in young apple trees made shortly before and after defoliation. J. Amer. Soc. Hort. Sci. 33:164-165.

4. Peynado, A. 1958. Devices for observing root growth and calipering tree trunks. J. Rio Grande Valley Hort. Soc. 12:61-66.

5. Schneider, H. 1952. The phloem of the sweet orange tree trunk and seasonal production of xylem and phloem. Hilgardia 21:331-366.

6. Snedecor, G. W. 1956. Statistical methods. 5th Ed. The Iowa State University Press. Ames, Iowa. 485 p.

Bower, A New Mandarin Variety for Texas

HEINZ K. WUTSCHER, NORMAN P. MAXWELL, and ARTHUR V. SHULL
Research Horticulturist, Subtropical Texas Area, Southern Region, ARS, USDA, Weslaco, Texas 78596; Assoc. Prof. Texas A&M Univ. Agr. Res. and Ext. Center, Weslaco, Texas; and Citrus Manager, Rio Farms, Inc., Monte Alto, Texas 78538, respectively.

ABSTRACT

A Clementine mandarin x Orlando tangelo hybrid (6-8-16) 'Bower' is released as a new variety for Texas. Bower is well adapted to South Texas conditions. The large and deeply colored fruit has potential for the fresh market and its juice is useful for processing.

From 1955 through 1965, the USDA in cooperation with the Texas Agricultural Experiment Station and Rio Farms, Inc. made intensive efforts to find new mandarins and mandarin hybrids suitable for Texas. A large number of new crosses made by USDA breeders in Indio, California and Orlando, Florida, were brought in and planted in preliminary test plot at Rio Farms in Monte Alto and the Texas A & M Univ. Rio Grande Plains Research-Demonstration Station at Crystal City. Second and third tests of selections from the original populations are still under way. No new introductions have been made since 1966. Potential varieties that appear well-adapted to Texas conditions are made available to interested growers and nurserymen.

Many new varieties that were accepted in Florida and California did not perform well in the Lower Rio Grande Valley (3). Of three varieties released in Texas, 'Orlando' tangelo and 'Fairchild' and 'Fortune' mandarin hybrids, only Orlando has been planted to any extent. Fairchild proved to be too small for market acceptance and the late-maturing Fortune is very acid in most years and ripens in March, an unfavorable time for mandarin sales.

The *Citrus reticulata* Blanco 'Clementine' tangerine x (*C. paradisi* Macfad. x *C. reticulata* Blanco) Orlando tangelo hybrid 'Bower', Selection 6-8-16, is the result of a cross made at the U.S. Hort. Res. Center in Orlando, Florida, in 1942. It was introduced into Texas in 1955, and fruit from test plantings sent to packing houses were readily accepted and brought requests for larger quantities. Local canners were enthusiastic about test samples of Bower juice for blending with early orange juice. Because test results at Rio Farms in Monte Alto and at Crystal City show that this selection is well adapted to Texas conditions, we decided to release it to interested growers and nurserymen as a variety under the name Bower.

DESCRIPTION

Bower trees are upright spreading with few thorns. The leaves are broadly lanceolate and the foliage is dense. The trees are vigorous and early producers. The fruit is oblate and medium to large, averaging about 3 inches in diameter, superior in size to other mandarin varieties, except satsumas, currently grown in Texas. The base and the apex are slightly depressed. Navels are common. The rind is creased slightly at the apex in some years; in Florida this creasing is severe (C. J. Hearn, personal communication), but it has not been a problem in Texas. The rind is thin, slightly bumpy and easily peelable. The color is a deep orange at maturity. The 13-15 segments are readily separable; the axis is large and hollow. The flesh color is deep orange, the fruit is juicy (50% juice) and has a pleasant flavor. There are 25 to 40 seeds with light green cotyledons. No pollination studies have been made, but experience with similar hybrids suggests that cross pollination is necessary for good fruit set.

YIELD

Rio Farms, from a 4-acre grove planted in 1966, with 2/3 of the trees on Cleopatra mandarin rootstock and 1/3 on sour orange, harvested 160 lb of fruit/tree, or 8.3 tons/acre in 1972. This is well above the mean of 6.3 tons/acre for speciality fruits in the area.

Results from other test plots at Rio Farms are as follows:

Rootstock	No. of trees	Age of trees in 1972 (Years)	Yield/tree (lb) 1972	Cumulative yield (lb) (4 harvests)
Sour orange	4	8	175	385
Sour orange	8	6	40	263
Morton citrange	8	6	84	307

Results from test plots at the Texas A&M Univ. Rio Grande Plains & Research and Demonstration Station at Crystal City are as follows:

Rootstock	No. of trees	Age of Trees in 1972 (Years)	Yield/tree (lb) 1972
Sour orange	10	6	63
Morton citrange	10	6	104

FRUIT QUALITY

Quality of fruit harvested in early December at Rio Farms (means of 4 years) is as follows:

Roostock	Age of trees in 1972 (Years)	Diameter inches	Total soluble solids %	Total acids %	Brix/acid	% Juice
Sour orange	8	2.92	12.9	1.16	11.12	49.7
Sour orange	6	2.93	13.4	1.19	11.26	51.8
Morton citrange	6	2.91	13.2	1.19	11.09	50.8

Quality of fruit harvested in early December at Crystal City (means of 2 years) is as follows:

Rootstock	Age of trees in 1972 (Years)	Diameter inches	Total soluble solids %	Total acids %	Brix/ acid	% Juice
Sour orange	6	2.66	14.6	1.61	9.06	48.4
Morton citrange	6	2.55	14.3	1.72	8.31	47.8

Bower juice is deep orange, better than USDA Standard OJ 1. Bower was tested with juice of four similar hybrids in Florida and after proper processing it was well-suited to strengthen the color of orange juice and effective in quantities as low as 5% (4). This effect on color and its fairly high acid content make Bower juice excellent for blending with 'Marrs' and other early orange juice.

COLD HARDINESS

The test plots in Crystal City have been exposed to repeated freezes with temperatures as low as 23 F with only leaf loss and minor twig damage. Comparatively, satsumas and Fairchild are somewhat more cold-hardy than Bower, but the differences are small (1, 2).

ROOTSTOCKS

Trials in both locations include six rootstock varieties: *Poncirus trifoliata* (L.) Raf. x *C. sinensis* (L.) Osbeck 'Morton'; *C. aurantium* L. 'Palestine sour orange' and 'Yama Mikan'; and *C. reticulata* Blanco 'Sun Chu Sha Kat', 'Changsha' and 'Cleopatra'. Data from the incomplete tests show that the highest yields are obtained on Morton citrange, with slightly better quality on sour orange.

AVAILABILITY OF BUDWOOD

Limited quantities of budwood can be obtained from the USDA Citrus Laboratory or from the Texas A & M Res. and Ext. Center in Weslaco.

LITERATURE CITED

1. Maxwell, N. P. 1967. Cold tolerance of several citrus varieties and strains on sour orange rootstock during a freeze in December 1966 at Crystal City, Texas. J. Rio Grande Valley Hort. Soc. 21:68-73.

2. Maxwell, N. P., and H. K. Wutscher. 1968. Freeze injury to young Fairchild and Bower tangerine trees on six rootstocks in the Winter Garden Area. J. Rio Grande Valley Hort. Soc. 22:10-15.

3. Olson, E. O., N. P. Maxwell, B. Sleeth, and B. Lime. 1966. Evaluation of 'Fairchild', 'Fortune' and other tangerine hybrids in Texas. J. Rio Grande Valley Hort. Soc. 20:97-101.

4 Scott, W. C., and C. J. Hearn. 1966. Processing qualities of new citrus hybrids. Proc. Florida State Hort. Soc. 79:304-307.

Characteristics of Phytophthora Isolates from Texas Citrus Orchards

L. W. Timmer
Asst. Prof., Texas A&I Univ. Citrus Center
Weslaco, TX 78596

ABSTRACT

Phytophthora isolates collected from Texas citrus orchards were all identified as *Phytophthora parasitica*. Under appropriate conditions, all isolates produced sporangia, oospores, and chlamydospores reasonably typical of the species. Both A^1 and A^2 mating types were recovered. The relationship of these findings to the local disease situation is discussed.

Phytophthora sp. cause serious damage to citrus trees in the Lower Rio Grande Valley. Foot rot is the primary symptom observed, but brown rot of the fruit and twig and leaf blights also occur. Olson (4) isolated a *Phytophthora* sp. from sour orange seedlings and demonstrated its pathogenicity to citrus seedlings, but did not identify the species involved. Sleeth (5) isolated *Phytophthora parasitica* Dast. [*P. nicotianae* var. *parasitica* (Dast.) Waterhouse] from active foot rot lesions. In California *P. parasitica, P. citrophthora* (Sm. & Sm.) Leonian, *P. hibernalis* Carne and *P. syringae* Kleb. attack citrus and each may cause serious damage under optimal conditions for the species (2). *P. parasitica* and *P. citrophthora* were the only species isolated from Florida citrus orchards (11). Little information is available on the species present in Texas or on the characteristics of local isolates. In this study, isolations were made from infected citrus and from citrus soils. All isolates were identified and characterized.

MATERIALS AND METHODS

Isolations of *Phytophthora* from soil were made using the lemon-trap technique (3). After the fungus from the soil had invaded the lemon, pieces of the infected fruit were plated on PVP (pimaricin, vancomycin, pentachloronitrobenzene) medium (8) to separate the fungus from bacterial and fungal contaminants. Pieces of infected bark, leaves, and fruit collected in the field were plated directly on PVP medium. Mycelium growing from infected plant material was transferred to and maintained on V-8 juice agar (V-8A) slants.

To assure that each isolate represented a single uncontaminated strain, single-zoospore isolates of each were made. Sporangia were produced by growing the fungus in clarified V-8 juice broth (6) for 2-3 days, washing the mycelial mat with sterile, deionized water, and incubating it in water 1-2 days. Zoospores were released after chilling sporangia for 15-20 min at 10 C and warming to room temperature (21-

27 C). Zoospores were plated on 1.5% water agar, allowed to germinate, and a single, germinated zoospore transferred to a V-8A slant.

In order to identify *Phytophthora* species all spore structures must be measured and the ability of each isolate to grow at 36 C must be determined. Sporangia and zoospores were produced as described above. Chlamydospores were produced by the method of Tsao (7). Mating type was determined and oospores obtained by placing the test culture in the center of a clarified V-8 juice agar plate and plating a known A^1 culture (T131) on one side of the plate and a known A^2 culture (P595) on the opposite side. Plates were incubated in the dark until cultures grew together and formed oospores (usually 7-10 days). Measurements of spore structures were made on a compound microscope using an eyepiece micrometer. At least ten measurements each of sporangia, chlamydospores and oospores were made to determine the average size of the spore structures for each isolate. Ability to grow at 36 C was determined by plating the isolates on corn meal agar, incubating at 36 C for 72 hr and measuring the colony diameter.

Most isolates were from the Texas A&I Citrus Center in Weslaco, but some from various parts of the Lower Rio Grande Valley were included (Table 1). Because *P. citrophthora* is more likely to be recovered from infected fruit and leaves, and *P. parasitica* is more likely to be recovered from foot rot lesions (11), isolations were made from soil and from infected plant parts.

RESULTS

The characteristics of each isolate (Table 1) fit the description of *P. parasitica* (10) more closely than that of any other species. The average sporangial size of all isolates, 49 x 39 u, was somewhat larger than that described for the species: 38 x 30 u (10). The dimensions of the oospores and chlamydospores of these isolates were typical of *P. parasitica.* Isolate S6 produced large sporangia with a 1.6:1 length-to-breadth ratio and did not produce oospores when mated with either P595 or T131. The sporangia of this isolate resemble those of *P. capsici* more than they do those of *P. parasitica*. However, S6 produced oospores when mated with isolates S5, S10, F3 and S11 and did not produce oospores with P504 (A^1) and P505 (A^2) of *P. capsici.* Also, S6 produced abundant chlamydospores while *P. capsici* does not produce chlamydospores. Consequently, S6 was classified as *P. parasitica* even though atypical. All isolates were able to grow at 36 C as is characteristic of *P. parasitica.* Colony diameters after 72 hr at 36 C ranged from 16 mm for S9 to 43 mm for L1.

Both the A^1 and A^2 mating types were recovered, but the A^1 type predominated (Table 1). All isolates produced abundant oospores when crossed with the opposite mating type. Most isolates released abundant zoospores after chilling the sporangia. However, S2 and S11 released relatively few zoospores considering the large number of sporangia pro-

Table 1. Characteristics of isolates of *Phytophthora* recovered from different sources and locations in the Lower Rio Grande Valley.

Isolate No.	Location	Source	Sporangia Production[a]	Sporangia Size (u)	L:B[b]	Mating Type	Oospore Size (u)	Chlamydospore Size (u)
B1	Mercedes	bark	++	50x38	1.3:1	A^1	26	33
B2	Texas A&I	bark	++	47x37	1.3:1	A^1	23	40
S1	Elsa	soil	+++	48x42	1.1:1	A^1	24	30
S2	Weslaco	soil	+++	53x43	1.2:1	A^1	23	32
S3	Weslaco	soil	+++	52x40	1.3:1	A^1	24	38
S4	Texas A&I	soil	+	49x39	1.3:1	A^1	24	30
F1	Texas A&I	fruit	+	46x38	1.2:1	A^1	24	35
L1	Texas A&I	leaves	+	47x42	1.1:1	A^2	25	34
F2	LaFeria	avocado	+	52x40	1.3:1	A^1	23	26
S5	Texas A&I	soil	++	50x39	1.3:1	A^2	24	53
S6	Alamo	soil	+	62x40	1.6:1	A^1	31	33
S7	Texas A&I	soil	++	50x39	1.3:1	A^1	25	36
S8	Alamo	soil	+++	52x38	1.4:1	A^1	24	30
S9	Alamo	soil	+++	42x33	1.3:1	A^1	31	33
S10	Mission	soil	+++	48x37	1.3:1	A^2	23	44
S11	Texas A&I	soil	++	46x38	1.2:1	A^2	24	45
F3	Edinburg	fruit	+	46x37	1.2:1	A^2	25	35

[a] + = sparse, ++ = moderate, +++ = abundant
[b] L:B = length-to-breadth ratio

duced. Using the method of Tsao (7), all isolates produced abundant chlamydospores in 2-3 weeks.

Isolate F2 was recovered from a decaying avocado fruit in a mixed planting of citrus and avocados. Recovery of the fungus from an avocado fruit does not necessarily imply that this isolate is pathogenic to avocado.

DISCUSSION

The only species of *Phytophthora* recovered from Valley citrus to date has been *P. parasitica*. While this does not exclude the possibility that other species may be present in the Valley, it indicates that the others are not common. In Florida, Whiteside (11) has associated outbreaks of brown rot of the fruit with presence of *P. citrophthora*. The apparent absence of *P.citrophthora* from the Valley explains the relatively minor importance of brown rot in this area.

The optimum temperature for growth of *P. parasitica* is high (30-32 C), while the optima for the other species that attack citrus are lower (20-27 C) (2). The absence of species with low temperature optima from this area explains why new foot rot infections seldom occur in winter. If other species had been present, it may not have been possible to use soil banks for frost protection as was done for many years.

Both mating types of *P. parasitica* were recovered from Valley citrus. Most of the isolates recovered were of the A^1 mating type, but the number of isolates studied was insufficient to draw any conclusions on the relative frequency of occurrence of the two mating types. The presence of both mating types implies that oospores may be produced under orchard conditions.

Although the role of oospores in the life cycle of *Phytophthora* is not well-established (9) they probably serve as survival structures and as a source of variation for the fungus. If oospores are produced in the field, the fungus may survive longer periods in the absence of a host than would otherwise be possible. The production of sexual spores also implies a greater potential for variation in the fungus. Thus, the possibility of the occurrence of new more virulent strains or of strains differing in host range is enhanced. Variation in the pathogenicity of different isolates to sweet orange seedlings has been demonstrated (1).

Since chlamydospores serve as survival structures in the life cycle of the fungus (9), abundant chlamydospore production by local isolates would increase the probability that these isolates would survive unfavorable periods.

ACKNOWLEDGMENT

I wish to thank D. C. Erwin, Univ. Calif., Riverside for the standard A^1 and A^2 isolates of *P. parasitica* and *P. capsici*.

LITERATURE CITED

1. Grimm, G. R., and R. Whidden. 1962. Range of pathogenicity of Florida cultures of the foot rot fungus. Proc. Fla. State Hort. Soc. 75:73-75.

2. Klotz, L. J. and E. C. Calavan. 1969. Gum diseases of citrus. Calif. Agr. Expt. Sta. Ext. Serv. Circular 396.

3. Klotz, L. J. and T. A. DeWolfe. 1958. Techniques for isolating *Phytophthora spp.* which attack citrus. Plant Dis. Reptr. 42:675-676.

4. Olson, E. O. 1959. Tip blight of citrus seedlings in the Lower Rio Grande Valley. J. Rio Grande Valley Hort. Soc. 5:72-76.

5 Sleeth, B. 1972. Treatment and recovery of footrot affected grapefruit trees. J. Rio Grande Valley Hort. Soc. 26:28-32.

6. Timmer, L. W., J. Castro, D. C. Erwin, W. L. Belser, and G. A. Zentmyer. 1970. Genetic evidence for zygotic meiosis in *Phytophthora capsici*. Amer. J. Bot. 57:1211-1218.

7. Tsao, P. H. 1971. Chlamydospore formation in sporangium-free liquid cultures of *Phytophthora parasitica*. Phytopathology 61:1412-1413.

8. Tsao, P. H., and G. Ocana. 1969. Selective isolation of species of *Phytophthora* from natural soils on an improved antibiotic medium. Nature 223:636-638.

9. Tsao, P. H. 1969. Studies on the saprophytic behavior of *Phytophthora parasitica* in soil, p. 1221-1230. *In* Chapman, H. D. [ed.] Proc. 1st Intl. Citrus Symp. Univ. Calif., Riverside. Vol. III.

10. Waterhouse, G. M. 1963. Key to species of *Phytophthora* De Bary. Mycol. Paper No. 92. Commonwealth Mycol. Inst. Kew, England. 22p.

11. Whiteside, J. O. 1970. Factors contributing to the restricted occurrence of citrus brown rot in Florida. Plant Dis, Reptr. 54:608-611.

Effect of Soil Fumigation with Vapam on the Growth of Sour Orange Seedlings

L. W. TIMMER
Asst. Prof., Texas A&I Univ. Citrus Center
Weslaco, TX 78596

ABSTRACT

The diameter of sour orange *(Citrus aurantium)* seedlings increased more rapidly in seedbed and nursery soils fumigated with Vapam before planting than in nonfumigated soil infested with *Phytophthora parasitica* and *Tylenchulus semipenetrans.*

Citrus nematode (*Tylenchulus semipenetrans* Cobb) and *Phytophthora parasitica* Dast. are common soil-borne parasites of citrus in the Lower Rio Grande Valley (3,6). Several preplant fumigants are available which control these pests (1,2,6), but fumigation is seldom used in local nurseries or orchards. Some of the possible advantages and disadvantages of soil fumigation have been pointed out (6). Sleeth (4,5) demonstrated that preplant nematicide treatment increased the growth of nursery trees planted on old orchard soils. However, little information is available on the effect of soil fumigation on the growth of seedlings in the seedbed or nursery.

Vapam effectively controls both nematodes and fungi (1) and was selected as the soil fumigant for this study. This work was undertaken primarily to determine the advantages or disadvantages of preplant fumigation of seedbed and nursery sites.

MATERIALS AND METHODS

Seedbeds. Two seedbeds, 1.2 x 2.0 x 0.5 m deep, were established in a partially shaded area. The soil mixture consisted of 1/3 peat, 1/3 sand, and 1/3 soil infested with *Phytophthora* and citrus nematode. One of the seedbeds was fumigated by adding 250 ml of Vapam 4S (sodium *N*-methyl dithiocarbamate) to sufficient water to thoroughly wet the seedbed (equivalent to 100 gal of Vapam per acre). The fumigated seedbed was covered with a plastic tarp for 48 hr following treatment. The nonfumigated bed received irrigation water only. Approximately one month after fumigation the seedbeds were planted with 700 seed each of sour orange (*Citrus aurantium* L.) and the seed covered with peat moss. Subsequently, seedbeds were watered and fertilized as needed.

Nursery plots. Nursery plots were established in an area where mature trees had been removed about one year earlier. The area was infested with *Phytophthora* and citrus nematode. Eighteen 3 x 3 m plots with permanent soil borders were established. Plots were separated by

3 m alleys. One month prior to planting each plot was flood irrigated with 750 liters of water. For each of the fumigated plots, one liter of Vapam was added to the irrigation water (equivalent to 100 gal/acre).

Approximately one month after fumigation, four rows of four seedlings each were planted in each plot. Treatments were: 1) seedlings from the fumigated seedbed planted in fumigated soil 2) seedlings from the fumigated seedbed planted on nonfumigated soil 3) seedlings from the nonfumigated seedbed planted on nonfumigated soil. Treatments were replicated six times and arranged in a completely randomized block design.

The diameter of each seedling was measured 3 cm above the soil line at the time of planting and 6 and 8 months later. Citrus nematode larvae were extracted from soil using a modified Baerman funnel technique and counted.

Plots were irrigated and fertilized with urea as necessary. Fumigated plots remained relatively weed-free for 10 weeks after planting, while nonfumigated plots were hoed twice during that time. Subsequently fumigated and non-fumigated plots were hoed at the same time.

RESULTS AND DISCUSSION

Seedbeds. Seed germination was 86.3% in the fumigated bed and 89.4% in the nonfumigated bed. No damping-off was observed in either case. Seedlings were measured when they were transplanted to the nursery plots. The number of seedlings in each height class from the fumigated and nonfumigated beds is given in Table 1. Fumigation prior to planting resulted in a considerable increase in the mean height of the seedlings.

Nursery. Although an attempt was made at the beginning of the experiment to randomly assign seedlings from the fumigated seedbed to

Table 1. Height distribution of sour orange seedlings from Vapam-fumigated and nonfumigated seedbeds.

Height class	*No. of seedlings/class*	
	Fumigated	*Nonfumigated*
>60 cm	4	0
50-60	22	0
40-50	54	0
30-40	125	7
20-30	159	106
<20	195	482
Mean height[1]	27 cm	17 cm

[1]The difference in mean height of seedlings from the fumigated and nonfumigated beds was significant at the 1% level according to the *t* test.

the plots of treatments 1 and 2, the average diameter of the seedlings in treatment 1, 0.37 cm, was significantly greater than that of those in treatment 2, 0.36 cm. The largest seedlings from the nonfumigated bed were used in treatment 3, but their average diameter, 0.31 cm, was significantly less than that of the seedlings from the fumigated bed. There were significant differences between all treatments when growth was measured as the increase in the diameter of the seedlings during the first 6 months (Table 2). When growth was measured as the percent increase in diameter, there was a significant difference between the fumigated and nonfumigated plots but the source of the seedlings did not affect this growth index (Table 2).

The seedling diameter at planting time also affected the subsequent growth of the seedlings. The smaller the original diameter, the faster the seedling diameter increased (Table 2). This effect occurred whether growth was measured as increase in diameter or as percent increase in diameter and did not seem to be affected by the treatments. In this respect, growth of transplanted seedlings is similar to that of nursery trees transplanted to an orchard. With young orchard trees, Fucik (unpublished results) found a significant negative correlation between initial trunk diameter and subsequent increase in trunk diameter.

Since smaller transplanted seedlings normally increase in diameter more rapidly and since the seedlings used in treatments 2 and

Table 2. Effect of preplant soil fumigation with Vapam and of initial stem diameter on the growth of sour orange seedlings.

Treatments			*Stem diam at planting (cm)*					
Seedbed	*Nursery*		*0.2*	*0.3*	*0.4*	*0.5*	*0.6*	*Means*
Fumigated	Fumigated	Incr.[1]	0.52	0.42	0.37	0.37	0.35	0.40[a2]
		%	260	139	92	74	57	109[a]
		No.	10	37	27	17	8	
Fumigated	Nonfumigated	Incr.	0.37	0.36	0.33	0.31	0.32	0.34[b]
		%	200	120	81	62	53	89[b]
		No.	10	38	34	9	5	
Nonfumigated	Nonfumigated	Incr.	0.36	0.27	0.26	0.40	—	0.28[c]
		%	179	89	66	80	—	90[b]
		No.	14	56	24	1	0	

[1]Incr.=Mean increase in stem diam (cm) first 6 months after planting
%=Mean % increase in stem diam first 6 months after planting
No.=Number of seedlings

[2]Mean separation in columns by Duncan's multiple range test, 5% level

3 were significantly smaller than those used in treatment 1, seedlings in treatments 2 and 3 would be expected to grow more rapidly. Thus, some of the beneficial effects of soil fumigation on growth may have been obscured by using larger seedlings in fumigated plots than were used in nonfumigated plots.

Heavy rains about 5 months after planting caused contamination of the fumigated plots by splashing infested soil from the areas between plots into fumigated plots. The average increases in stem diameter between 6 and 8 months after planting were not significantly different from one another. Counts of citrus nematode larvae confirmed suspected reinfestation of the fumigated plots. The number of larvae per 100 ml of soil averaged 157, 483, and 495 for treatments 1, 2, and 3 respectively. Although they had become contaminated fumigated plots still had significantly fewer nematodes than nonfumigated plots 8 months after planting.

Sour orange seedlings increased in diameter more rapidly in seedbeds and nurseries which had been fumigated than in nonfumigated, infested soils. Vapam effectively controls *Phytophthora* and citrus nematode (1) and no effort was made to distinguish between the effects of the two parasites. Since sour orange is resistant to *Phytophthora,* the growth response was presumed to be due primarily to control of citrus nematode. The seedling diameter at planting time also affects subsequent growth of the seedlings. Since small seedlings increased in diameter more rapidly than larger ones, nurserymen should consider transplanting seedlings earlier than they presently do.

In this experiment, the fumigated plots became reinfested before the seedlings were ready to bud and no further response to fumigation was observed. However, where larger, more isolated areas are fumigated, it would be easier to prevent reinfestation and a continued difference between fumigated and nonfumigated soils would be expected. Sour orange seedlings increase in diameter more rapidly on Vapam-fumigated soil than on soils infested with root parasites. If reinfestation of seedbed and nursery sites can be prevented, it may be possible to produce nursery stock relatively free of these pests.

LITERATURE CITED

1. Baines, R. C. 1957. Results with Vapam to control nematodes, fungi. Calif. Citrog. 42:192,202,204-209.

2. Baines, R. C., F. J. Foote, and J. P. Martin. 1957. Fumigate soil before replanting to control citrus nematode. Calif. Citrog. 41:427,448-450.

3. Heald, C. M. 1970. Distribution and control of the citrus nematode in the Lower Rio Grande Valley of Texas. J. Rio Grande Valley Hort. Soc. 24: 32-35.

4. Sleeth, B. 1958. Soil fumigation increases growth of citrus replants. J. Rio Grande Valley Hort. Soc. 12:53-56.

5. Sleeth, B. 1962. Response of citrus replants to soil fumigation in south Texas. J. Rio Grande Valley Hort. Soc. 16:59-64.

6. Timmer, L. W. 1972. Management of soil-borne diseases of citrus in the Lower Rio Grande Valley. J. Rio Grande Valley Hort. Soc. 26:44-58.

Control of Citrus Pests with Postbloom Oil Application

REX B. REINKING
Asst. Prof., Texas A&I Univ. Citrus Center
Weslaco, TX 78596

ABSTRACT

Petroleum spray oils at 0, 0.5, 1.0 and 1.5% were used on grapefruit as a postbloom application. Over the 7-year test period the 1.5% oil had significantly more scale-free fruit than all the other treatments. Lower rates of oil did not give consistently better scale control than the non-oil check. None of the treatments affected production except for one year when the oil treatments resulted in lower yields.

Citrus spray oils have been used in the United States for controlling orchard pests for many years. These oils offer a number of advantages in the pest control program besides their ability to kill certain mites and scale insects (2). Pests do not develop a resistance to spray oil because of its mode of action. It is less harmful to beneficial insect populations than many other pesticides, causes sooty mold fungus to slough off from leaves and fruit, and is an excellent spreader-sticker. Spray oils pose no hazard to the environment or applicator and are generally more economical to use than other pesticides. However, when not used properly with respect to soil moisture, humidity, and temperature, spray oil can cause fruit drop, leaf drop, and twig damage.

Spray oils have been used as a summer scalicide application on citrus in Texas since the 1920's. Postbloom oil sprays are recommended in Florida for the control of scale insects and spider mites (1). Previous work in Texas indicated there may be some merit to a postbloom oil spray for scale and mite control (3). Because of the possibility of improved scale control and the lost cost of spray oil compared to other materials further investigation into the use of oil in the postbloom spray has been conducted.

MATERIALS AND METHODS

Ruby Red grapefruit trees planted in 1950 and interplanted in 1960 were used for the experiment. The test block was located at the Texas A&I University Citrus Center, Weslaco, Texas. The postbloom treatments were: 0.5%, 1.0%, and 1.5% citrus spray oil and a non-oil control with 1½ pint 42% EC Kelthane M.F. (dicofol; 1, 1-bis (p-chlorophenyl)2, 2, 2-trichloroethanol) in 100 gal of water. Zineb (zinc ethylenebisdithiocarbamate) or chlorobenzilate (ethyl 4, 4'-dichlorobenzilate) and a copper fungicide were added to each spray treatment. These postbloom applications were made each year in April after the trees had bloomed and were the only variables in the pest control program. A regular spray schedule was continued on all plots during the remainder of the year. The test plots were arranged in a 4 x 4 Latin Square. Data was taken from four test trees (two mature and two interplanted) per plot.

Armored scale control was determined by counting the number of clean fruit (fruit with 5 scales or less) in a 50-fruit sample taken at random from each tree in the plots. Control of other pests was determined by field observation and laboratory inspection. Yield was obtained by weighing the fruit from each tree.

RESULTS AND DISCUSSION

Armored scale consisted primarily of California red scale (*Aonidiella aurantii* Mask.) and chaff scale (*Parlatoria pergandii* Comst.). Averaged over all years the postbloom application of 1.5% oil gave significantly better scale control than the other oil sprays and the non-oil treatment (Table 1). While the comparative effectiveness of the 0.5 and 1.0% oil and non-oil treatments varied from season to season, over all the years there were no differences in scale control between these treatments.

With the exception of 1966 when the trees sprayed with oil yielded less than the non-oil sprayed trees, none of the treatments significantly affected yields (Table 2). As might be expected the greatest variation in grapefruit yields was between years. The statistical analysis showed these yearly yield variations were unrelated to the postbloom spray applications. No yields were taken in 1967 because of Hurricane Beulah.

Postbloom sprays with and without oil controlled rust mite and Texas citrus mite until the summer application.

Table 1. Percentage scale-free grapefruit on trees sprayed after bloom with different rates of oil.

	Years							
Treatment	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*Ave. for all years*
0.5% Oil	58 bc*	11 b	87a	83ab	73a	85a	87a	66 b
1.0% Oil	70 b	20ab	88a	84ab	75a	90a	74 c	71 b
1.5% Oil	84a	41a	90a	94a	80a	90a	79 bc	79a
Non-Oil Kelthane	44 c	15 b	88a	77 b	61 b	87a	85ab	62 b

* Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 2. Average yield of grapefruit (lb/tree) on trees receiving three rates of oil and one non-oil postbloom spray.

Treatment	*Years*						*Mean for Treatment*
	1965	*1966*	*1968*	*1969*	*1970*	*1972*	
		Old Line and Interplants					
0.5% Oil	201a*	394 b	264a	365a	361a	317a	318a
1.0% Oil	196a	399 b	299a	355a	365a	294a	318a
1.5% Oil	202a	331 b	291a	326a	383a	290a	305a
Non-Oil Kelthane	128a	470a	294a	330a	386a	368a	334a
Mean for Years	182	399	287	344	369	317	

* Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

LITERATURE CITED

1. State of Florida Department of Citrus. 1972. Florida Citrus Spray and Dust Schedule.

2. Ebeling, Walter. 1959. Subtropical Fruit Pests. Univ. Calif. Div. Agr. Sci. 436 p.

3. Thomas, H. A. 1960. Chemical spray trials for the control of mites on citrus. J. Rio Grande Valley Hort. Soc. 14:33-39.

California Red Scale Populations As Affected By Certain Scalicide Treatments

H. A. DEAN and ART SHULL

Assoc. Prof., Texas A&M Univ. Agr. Res. and Ext. Center at Weslaco, TX, 78596 and Citrus Production Manager, Rio Farms, Inc., Monte Alto, TX, 78538

ABSTRACT

Three programs produced effective and economical control of California red scales, *Aonidiella aurantii*, in a grapefruit grove at Monte Alto, Texas during 1969-71. The smallest numbers of scales and parasites were found in plots treated with 10 gal oil + ethion at postbloom followed with 15 gal oil + ethion during the summer. These plots, however, developed a brown soft scale problem in August 1972, after all plots were treated alike. All plots received 15 gal oil during the summer. Only 8% more live scales were found in all records from plots where chlorobenzilate-dicofol were applied at postbloom in comparison with plots where 15 gal oil plus zineb were used.

The California red scale, *Aonidiella aurantii* (Mask.), has become increasingly more important as a pest of citrus in the Lower Rio Grande Valley of Texas during the past few years. Increases in populations of this scale insect have resulted from certain scalicides not providing adequate control, inadequate coverage with the scalicides employed and upsets in the beneficial-scale insect relationship. Prior experiences with this scale insect have shown that beneficial insects could provide adequate control in many instances. An experiment was initiated during the spring of 1969 at Rio Farms, Inc. at Monte Alto to determine the relative effectiveness of three programs for control of this scale insect.

The chaff scale, *Parlatoria pergandii* Comstock, has been the most widely distributed and most abundant diaspidid scale insect on Rio Grande Valley citrus (3, 4). Its control by chemical and biological means has been more thoroughly investigated in Texas than that of other diaspidid scales. Chaff scales are often mistaken for California red scales by growers. More red scale-infested fruit are culled when comparable numbers of California red scales and chaff scales are present because the latter are more easily brushed from the fruit.

Early work showed California red scales to have overlapping generations in our area with maximum numbers of young scales found during the summer and fall months (2). Clark (1) reported *Aphytis chrysomphali* (Mercet), along with others, as the most abundant scale parasites during the 1935-37 period. This species was the first mentioned parasite in Clark's report and is known to be parasitic on California red scales. DeBach (5) reported that this species and *Aphytis lignanensis* Compere seemed to be controlling this scale insect in the Texas citrus area. *A. chrysomphali* has been replaced entirely by *A. lignanensis* at the present time and all parasitism records on which this paper is based were considered to be due to *A. lignanensis*.

MATERIALS AND METHODS

Grapefruit trees used in these tests were 13 years old ranging from 8 - 12 ft in height and were planted 15 x 25 ft apart. Each plot was 12 rows wide, had 22 -27 trees per row, and was approximately 3 1/3 acres. Treatments were randomized within each 10-acre block and replicated three times.

The three postbloom treatments consisted of the following amounts of the respective formulations per acre: ½ gal 45.5% EC chlorobenzilate (ethyl 4,4'-dichlorobenzilate) + 1 gal 42% EC dicofol (1,1-bis(p-chlorophenyl) 2,2,2-trichloroethanol) (Kelthane); 10 gal 99.65% oil + 1 gal 46.5% EC ethion (0,0,0',0'-tetraethyl S, S'-methylenebisphosphoro-dithioate); and 15 gal 99.65% oil + 10 lb 75% WP zineb (zinc ethylene bisdithiocarbamate). All treatments received 15 gal oil in summer treatmeat with treatments 1 and 3 including 10 lb zineb while treatment 2 included 1 gal ethion. The oil had a 50% distillation point at 10 mm Hg of 443 with a 10 - 90% distillation temperature range of 75 F. Application dates were as follows: 6-7 May, 13-14 Aug. 1969; 30 Apr - 1 May, 31 July - 3 Aug 1970; and 17-18 May & 26-27 Jul 1971.

Two 97,500 ft^3/min air blast sprayers with two sets of nozzles on each side were operated at 125 psi to apply the various sprays. Sprayers were pulled at 1 mph and the dilution rate was 2X (500 gal/acre). About 60% of the liquid was directed into the top half of the trees.

Records of live and parasitized scale insects were made according to a described method (4).

RESULTS AND DISCUSSION

The peak of live scales/100 leaves occurred each year just prior to the postbloom application of pesticides (Table 1). The numbers of live parasites were usually quite small during this period with the scale : parasite ratio varying from 5.2 - 10.4 to 1 in 1969, 0.91 (incomplete scale collection from oil-ethion plots) - 7.8 to 1 in 1970, and 2.0 - 5.6 to 1 in 1971. Sulfur dust at 85 lb/acre was applied by air to the entire experiment on 21 Mar 1971 for citrus rust mite control. Scale numbers continued at a high level prior to postbloom sprays on May 17 and 18 of that year. Parasites increased in numbers after the sulfur dust application but declined in most plots by May 10.

Live scale numbers declined to 6.25 or less following the 15 gal of oil/acre in May of 1969 and 1970, but decreased only to 24.2 in 1971 after the late May application. Populations then increased sharply, except in 1971. Parasite numbers were quite small after postbloom and prior to summer application. The largest increase of scales after summer application in these plots was found in 1970, although in all years consider-

Table 1. Populations of California red scales and their parasites as affected by various treatments in a grapefruit grove at Monte Alto, Texas, 1969-72.

Sampling Date	*Spray[a] Date*	A				B				C			
		S[b]	P[c]	NS[d]	NL[e]	S	P	NS	NL	S	P	NS	NL
4/22/69		62	11.4	252	192	72	7.3	230	192	64	9.0	219	192
	5/6	15 gal oil + 10 lb zineb				0.5 gal chlorobenzilate + 1.0 gal dicofol				10 gal oil + 1.0 gal ethion			
6/2		6	0.0	181	192	71	26.6	283	192	1	0.0	200	192
8/4		23	0.0	192	192	87	4.0	314	192	0	0.0	168	192
	8/13	15 gal oil + 10 lb zineb				15 gal oil + 10 lb zineb				15 gal oil + 1.0 gal ethion			
9/9		36	2.1	209	192	7	0.0	302	192			f	
11/3		28	5.7	201	192	68	5.2	348	192	1	0.0	145	192
1/13/70		62	3.6	216	192	45	3.1	273	192			f	
2/17		77	2.1	229	192	49	4.2	224	192			30	30[f]
4/20		81	16.1	238	192	90	11.5	265	192	84	9.0	102	91[f]
	4/30;5/1	15 gal oil + 10 lb zineb				0.5 gal chlorobenzilate + 1.0 gal dicofol				10 gal oil + 1.0 gal ethion			
6/1		6	0.0	244	192	74	19.8	309	192			f	
7/21		62	0.0	209	160[f]	86	0.5	334	192			f	
	7/31;8/3	15 gal oil + 10 lb zineb				15 gal oil + 10 lb zineb				15 gal oil + 1.0 gal ethion			
10/19		56	8.8	178	160	20	4.7	217	160			f	
1/25/71		75	12.5	335	192	54	5.2	364	192			52	48[f]
3/2		99	15.1	280	192	93	14.1	311	192			22	26[f]

(Continued)

Table 1 (Continued)

	3/21					...... Sulfur Dust by Airplane							
4/21		83	30.7	302	192	86	32.3	264	192	73	25.0	229	192
5/10		119	56.6	499	166	93	16.1	428	188	68	14.0	223	192
	5/17,18	15 gal oil + 10 lb zineb				0.5 gal chlorobenzilate + 1.0 gal dicofol				10 gal oil + 1.0 gal ethion			
6/28		24	8.6	444	186	72	3.6	494	187	4	0.0	268	192
	7/26,27	15 gal oil + 10 lb zineb				15 gal oil + 10 lb zineb				15 gal oil + 1.0 gal ethion			
8/23		12	0.0	344	192	7	0.0	437	191	0	0.0	243	192
10/13		43	0.0	358	192	20	5.7	318	192	1	0.0	263	192
1/12/72		27	3.1	284	192	17	3.1	482	189			[f]	
2/2		58	1.6	350	192	22	2.1	326	192	3	0.5	205	192
3/6		73	2.6	295	192	38	3.6	436	192	22	1.6	202	192

[a] Per acre rates.
[b] Live scales/100 leaves.
[c] Immature parasites /100 leaves.
[d] Total number of scales observed in samples.
[e] Number of leaves for count of all treatment samples.
[f] Insufficient scales for comparative count.

able time was necessary to collect sufficient scale samples for evaluation. Following summer application, scale numbers usually declined somewhat in the early fall and then increased, particularly during the January - March period. Insufficient information is available as to the number of parasites to a given number of scales necessary to maintain non-economic numbers of California red scales. Parasite numbers were greatest when the scale numbers were greatest.

Selective acaricide (at postbloom) plots had greater numbers of live scales during the 2 - 4 months prior to the summer (August) oil application each year. The increase and decrease of live scale and parasite numbers closely paralleled each other. Parasite numbers reached a peak in June of 1969 and 1970 and in April 1971. Following the application of 15 gal of oil to these plots in late July or in August, live scale numbers were reduced to 20 or less before an increase was found during the fall season. However, this increase was not as great as that which occurred during the early part of the year. Although an extended peak of scale populations occurred during the summer in these plots, the total numbers of live scales in all records following post-bloom in 1969 were only 8% greater than in plots where 15 gal of oil were applied in both the postbloom and summer applications.

Live scale numbers were reduced to a low level after 10-gal-oil-ethion and 15-gal-oil-ethion postbloom and summer applications. Sharp increases were found 1 - 3 months prior to postbloom applications. Due to small scale numbers, it was difficult to make adequate collections from these plots on numerous occasions. The small numbers of scales made it difficult to find parasites. Except in the 20 Apr 1970 count, parasites were either non-existent or present in smaller numbers than in plots of other treatments. Oil + zineb, or chlorobenzilate, was the treatment applied by the grower in equal numbers of rows of each treatment plot after the last application (26 - 27 Jul 1971). A mixture of carbaryl (1-naphthyl N-methylcarbamate)-dicofol was applied to two of the three replicates in November 1971. However, in August 1972, brown soft scales were obviously predominant in plots where oil-ethion had been used during 1969-71.

California red scale was the only diaspidid scale of importance in this experiment. At the largest average level of 0.55 live scale/leaf their numbers were not large enough, however, in any treatment plot to cause the fruit to be downgraded.

ACKNOWLEDGEMENT

Participation in support of these investigations by Rio Farms, Inc., at Monte Alto, Texas, in providing and maintaining the grove is gratefully acknowledged. Thanks are also due Niagara Chemical Division of Food Machinery Corporation for providing the ethion used in these investigations.

LITERATURE CITED

1. Clark, S. W. 1937. Annual report. Tex. Agr. Exp. Sta. No. 15, Weslaco. (Unpublished)

2. Clark, S. W., and W. H. Friend. 1932. California red scale and its control in the Lower Rio Grande Valley of Texas. Tex. Agr. Exp. Sta. Bull. 455. 35 p.

3. Dean, H. A. 1955. Factors affecting biological control of scale insects on Texas citrus. J. Econ. Entomol. 48:444-447.

4. Dean, H. A., and C. E. Hoelscher. 1969. Chaff scale and chaff scale parasite populations as affected by selected petroleum oil fractions and various other pestisides. Tex. Agr. Exp. Sta. Misc. Publ. 927. 20 p.

5. DeBach, P. 1951. Possibilities in biological control of citrus pests. Rio Grande Valley Hort. Inst. Proc. 5:77-80.

Glyphosate and MSMA for Control of Perennial Weeds in Texas Citrus Orchards

ARLEN D. KLOSTERBOER
Asst. Prof.
Texas A&I Univ. Citrus Center
Weslaco, Texas 78596

ABSTRACT

Glyphosate (*N*-(phosphonomethyl) glycine) at 1.5 and 3.0 lb/acre gave excellent control of rhizome johnsongrass *(Sorghum halepense)*, established guineagrass (*Panicum maximum*) and purple nutsedge (*Cyperus rotundus*). Repeated applications of glyphosate at 1.5 and 3.0 lb/acre provided excellent control of the above mentioned species and bermudagrass (*Cynondon dactylon*) up to 5 months after initial treatment. Either as single or repeated applications, glyphosate at 1.5 and 3.0 lb/acre controlled perennial weeds better than MSMA (monosodium methanearsonate) at 2.0 lb/acre. Visual observations indicated that neither glyphosate nor MSMA injured citrus trees appreciably when applied as directed sprays although limited defoliation occurred.

The use of oil for weed control in citrus orchards was the beginning of a new cultural practice in citrus (1, 2). The chemical era was further advanced by the development of residual herbicides in the 1950's and early 1960's (3, 4, 5) and resulted in a more efficient and less expensive means of weed control. At the present time there are approximately 12 herbicides registered for use in Texas citrus orchards. The suggested weed control program recommends a preemergence herbicide application in the spring and in the fall. Orchards are also spot treated two to four times per year to control weeds that have escaped the preemergence treatment. Despite intensive use of herbicides, many perennials such as johnsongrass *(Sorghum halepense* (L.) Pers.), purple nutsedge *(Cyperus rotundus* L.), and bermudagrass *(Cynondon dactylon* (L.) Pers.) are not easily controlled. A study was initiated to determine the efficacy of single and repeated applications of glyphosate (*N*-(phosphonomethyl) glycine) and MSMA (monosodium methanearsonate) to control perennial weeds in citrus.

MATERIALS AND METHODS

Field experiments were conducted at the Texas A&I University Citrus Center, Weslaco, Texas. One experiment was established in a noncrop area heavily infested with johnsongrass and guineagrass (*Panicum maximum* Jacq.). A second experiment was conducted in a one year-old nursery of red grapefruit trees on sour orange rootstock. The nursery had an established stand of purple nutsedge and bermudagrass. Glyphosate and MSMA were applied postemergence as single and repeated applications. A randomized complete block design was used with three applications. Herbicides were applied with a CO_2 pressurized hand sprayer operating at 40 psi using water as a diluent at a spray volume of 40 gal/acre. Treatments are presented in Tables 1 and 2. Vegetation was flowering to nearly mature on the initial treatment dates. The second and third applications were made when vegetative regrowth was in the 4 to 8-leaf stage.

Weed control was visually determined on a scale of 0 to 100, with 0 indicating no control and 100 complete control. Ratings were made 4 or

Table 1. Percent control of johnsongrass and guineagrass with single and repeated applications of glyphosate and MSMA.

Herbicide	*Rate (lb/acre)*	*Weed Control*			
		Johnson-grass		*Guinea-grass*	
		IC[a]	*RC*[b]	*IC*	*RC*
GLYPHOSATE	1.5	94	15	93	40
	1.5 + 1.5	—	5	—	90
	1.5 + 1.5 + 1.5	—	95	—	100
	3.0	97	20	98	50
	3.0 + 3.0	—	8	—	93
	3.0 + 3.0 + 3.0	—	95	—	98
MSMA	2.0	74	25	67	22
	2.0 + 2.0	—	33	—	15
	2.0 + 2.0 + 2.0	—	65	—	73

[a] Initial control — 5 weeks after initial application
[b] Residual control — 10 weeks after third application

Table 2. Percent control of purple nutsedge and bermudagrass with single and double applications of glyphosate and MSMA.

Herbicide	*Rate (lb/acre)*	*Weed Control*			
		Purple-nutsedge		*Bermuda-grass*	
		IC[a]	*RC*[b]	*IC*	*RC*
GLYPHOSATE	1.5	78	90	55	57
	1.5 + 1.5	—	98	—	77
	3.0	96	88	65	72
	3.0 + 3.0	—	98	—	96
MSMA	2.0	72	23	30	0
	2.0 + 2.0	—	33	—	2

[a] Initial control — 4 weeks after initial application
[b] Residual control — 10 weeks after second application

5 weeks after initial treatment and 10 weeks after last treatment. Visual observations were made of trees to detect injury.

RESULTS AND DISCUSSION

Results indicate that 96 to 98% control of johnsongrass, guineagrass and purple nutsedge was obtained with initial applications of glyphosate at 3.0 lb/acre (Tables 1 and 2). Glyphosate at 1.5 lb/acre provided excellent early control of johnsongrass and guineagrass and good control of purple nutsedge. A single application of MSMA resulted in fair control of these species. Bermuda grass was not satisfactorily controlled with single applications of MSMA at 2.0 lb/acre or glyphosate at 1.5 lb/acre.

Visual examination indicated nearly complete deterioration of johnsongrass rhizomes and purple nutsedge tubers taken from plots treated with single applications of glyphosate. This observation and the lack of regrowth from established stands of perennial weeds is evidence that glyphosate is translocated in phytotoxic amounts to all parts of the plant. Phytotoxic symptoms on these perennial weeds were apparent earlier with MSMA than with glyphosate, however, residual control was longer with glyphosate. Therefore, the interval between repeated applications was approximately 5 weeks for MSMA and 8 weeks for glyphosate.

Three applications of glyphosate at 1.5 and 3.0 lb/acre provided excellent residual control of established johnsongrass and guineagrass for 10 weeks after final treatment (Table 1). The data in Table 1 indicate that single and double applications of glyphosate did not provide long term control of johnsongrass. A single application of glyphosate eliminated the early competition from guineagrass thus seedling johnsongrass growth flourished resulting in poor control ratings for johnsongrass. However, good control of rhizome johnsongrass was achieved with single and double applications of glyphosate. Although single and repeated applications of MSMA did not satisfactorily control johnsongrass and guineagrass, three applications resulted in fair control.

Single and double applications of glyphosate at 1.5 and 3.0 lb/acre gave excellent control of purple nutsedge 10 weeks after the second application (Table 2). Single applications of glyphosate at 1.5 and 3.0 lb/acre gave 57% and 72% residual control of bermudagrass, respectively, a double application at 3.0 lb/acre was required to obtain excellent control. At rates below 1.5 lb/acre glyphosate may be selective to bermudagrass. Long-term control of purple nutsedge and bermudagrass was not achieved with single or double applications of MSMA. At the rates used in this study, glyphosate controlled perennial grasses and purple nutsedge better than did MSMA.

Although limited defoliation of citrus occurred with directed foliar applications of glyphosate and MSMA, no permanent tree injury was observed on non-bearing trees. The use of glyphosate in a weed control program which includes preemergent herbicides to control seedlings has definite applicability to weed control in Texas citrus orchards.

LITERATURE CITED

1. Johnston, J. C., and W. Sullivan. 1949. Eliminating tillage in citrus soil management. Calif. Agr. Ext. Serv. Circ. 150. 16 p.

2. Leyden, R. F. 1959. Relation of cultural practices to soil moisture depletion in a young orchard. J. Rio Grande Valley Hort. Soc. 13:102-107.

3. Leyden, R. F. 1964. Chemical weed control with no tillage: A cultural practice for Texas citrus orchards. J. Rio Grande Valley Hort. Soc. 18: 25-28.

4. McCarty, C. D., B. D. Day, and R. C. Russell. 1960. Effect on monuron on lemon fruit quality. Cal. Cit. 45:174.

5. McCown, J. T., and D. W. Kretchman. 1961. The status of chemical weed control in Florida citriculture. Proc. Fla. State Hort. Soc. 74:46-50.

Observations on Citrus Leaf Drop in South Australia

M. R. Till and S. Z. Hyder
Senior Soils Officer and former Horticultural Research Officer,
Dept. of Agr. Adelaide, South Australia, 5001.

ABSTRACT

Fallen leaves were collected periodically from beneath well grown 6-year-old Valencia orange trees growing on a non-saline sandy soil. The leaves were analysed for sodium. In two of three spring periods the rate of leaf drop was greatest in October; in the third year, in December. Sodium contents were generally lowest during the winter when the rate of leaf drop was least and highest during spring. The sodium content reached a maximum of 28.8 meq per 100g dry weight during the spring.

In South Australia 6,400 ha of citrus trees are irrigated from the River Murray. Most are grown on deep sandy soils irrigated by overhead sprinklers but some are on shallow sodic soils and furrow watered. The climate is relatively mild, temperatures in summer (January) occasionally reaching 40 C but seldom falling to freezing point in winter (June). Rainfall averaging 300 mm per annum falls mainly in the winter months and irrigations totalling 1000 mm are applied August through April.

In some years an excessive leaf drop occurs on most citrus trees in this area. This has a serious effect on health and productivity of the trees. Reports of this condition over the past 30 years have been reviewed by Till (2) and some of the data from that paper are used here.

Although some leaf drop continues throughout the year, citrus trees drop more leaves between the beginning of the spring growth flush in September and blossoming and fruit set in late October than at other times of the year. The present investigation was undertaken to ascertain more precisely when leaf drop occurs. Fallen leaves were analysed to find the amount of salt they add to the soil beneath the trees. Possible causes of leaf drop were not specifically investigated in this preliminary investigation.

METHODS

In a citrus orchard in the Golden Heights Irrigation Area at Waikerie, South Australia, three adjacent trees were selected. They were well grown and healthy six-year-old Valencia orange trees which at the end of the experiment were 3.4 m high and 3.3 m in diameter.

All the leaves beneath the trees were removed in August 1966 and each tree surrounded by a wire-netting fence. Thereafter until December 1968 the leaves were collected from beneath each tree on 24 occasions at irregular intervals of from 6 days to 3 months. The leaves were shaken free of sand, dried, weighed. A sub-sample of all samples was analysed for sodium, potassium and chloride and of some for calcium, lithium, nitrogen and boron. Only the sodium data are presented here. A full report of the analyses is available from the senior author.

The soil was a deep coarse sand, non-saline and alkaline (maximum conductivity of saturation extract to 1 metre was 1.5 milli Siemens/cm at 25 C, pH 8.2 below 10 cm). The trees were irrigated by overhead sprinklers except between January and August 1968 when under-tree sprinklers were used. The annual application was about 100 cm in 20 irrigations applied fortnightly in summer and monthly in winter. The total duration of irrigation was approximately 200 hr per annum. The salinity of the irrigation water was high during the experiment, exceeding 210 mg/liter of chloride during the winter of 1966 and reaching 330 mg/liter of chloride in the summer of 1967-68. During the 1966-67 summer and again during the later part of 1968 the salinity was below 120 mg/liter chloride and dropped as low as 50 mg/liter.

RESULTS AND DISCUSSION

The progressive total weight of leaves collected was plotted to determine the rate of leaf fall in grams per day for each month. The sodium content of the leaves in a particular month was also found by graphical interpolation.

The results are shown in Table 1.

The first shoots appeared in the last week of August in 1966 and in mid-August in 1967. In these two seasons the amount of leaf drop increased rapidly through August and continued at a high level for the next 2 months. This confirms the general observation of the annual cycle of the intensity of leaf drop. In 1968 the commencement of shoot growth was not looked for. Both leaf drop and salinity was lower in this year and possible reasons for this are considered below.

Leaves weighed approximately 0.5 g each. The total weight of leaves, including those under the trees at the start of the experiment, was 8,800 g, representing approximately 18,400 leaves. The total weight of sodium chloride was 94 g. Salt in the fallen leaves is therefore not an important source of salt to the tree.

The fallen leaves may have lost salt as they lay under the trees by leaching by rain or irrigation, or they may have gained salt by irrigation water drying on them. These processes would influence the measured leaf sodium in opposite directions, and both are unlikely to have occurred because the leaves were sheltered beneath the canopy and because they lay there for only a short time. The measured sodium of the leaves is therefore likely to be a good indication of the leaf content of this element.

A noticeable feature of the data is that the sodium content of the leaves is high when the rate of leaf drop is high. Because the soil salinity is low, the sodium in the leaves is most likely gained by foliar absorption from irrigation water applied overhead. The salinity of leaves falling at a particular time may reflect the amount absorbed since their initiation (probably not more than the spring before last). In this case the salinity of the fallen leaves may be the result of the salinity of the irrigation water over this period and the amount of leaf drop the result of this high salinity. On the other hand the salinity of the leaf may be due to translocation of sodium chloride into the leaves prior to their senescence and abscission. If this were so the salinity of the leaf would be the result of its falling not the cause. In water culture experiments for instance, Hyder (1) found that fallen leaves had higher sodium (and chloride) contents than leaves of similar age remaining on the tree. It would not be logical to attempt to relate the amount of leaf drop in any

Table 1. Rate of leaf drop and sodium content of fallen leaves for Valencia oranges at Waikerie, South Australia, September, 1966 to December, 1968.

Month	*Rate of Leaf Drop (g per day)*	*Sodium Content of Leaves (meq. per 100 g)*
1966		
September	14.9	26.6
October	33.4	25.9
November	24.9	25.4
December	26.6	16.4
1967		
January	3.5	21.3
February	3.0	18.8
March	3.3	15.1
April	3.2	15.1
May	3.5	14.8
June	2.0	15.0
July	0.7	15.2
August	4.0	15.5
September	16.3	23.5
October	37.3	28.8
November	15.0	25.0
December	7.0	22.9
1968		
January	12.0	27.5
February	8.7	24.7
March	4.0	19.7
April	3.3	23.1
May	2.0	23.2
June	1.0	14.6
July	3.7	6.5
August	6.3	9.3
September	7.3	12.2
October	11.7	13.6
November	13.3	12.4
December	17.7	11.1

month with the leaf sodium content. Nor can the data be used to accurately establish critical sodium or chloride levels. The low sodium and low leaf drop in the 1968 summer may be related to the change to under tree sprinklers during the period January to August 1968 when water salinity was high. However, leaf drop was not as severe in any orchard in these districts during 1968 as it had been in previous years irrespective of the method of irrigation.

It was not possible with this data to relate leaf drop, sodium content and water salinity. The investigation was exploratory and the data are presented as guidelines for future research.

REFERENCES

1. Hyder, S. Z. 1969. Sodium chloride uptake and distribution in citrus seedlings. Sind Univ. Res. J. (Sci. Ser.) 4: 53-58.

2. Till, M. R. 1969. Timing and design criteria for irrigation of citrus, p. 1731-1748. *In* Chapman, H. D. (ed.), Proc. 1st Int. Citrus Symp. Univ. Calif., Riverside. Vol. III.

The Growth Curve For An Avocado Graft

J. E. CHANCE
Assoc. Prof. of Mathematics
Pan American Univ.
Edinburg, TX 78539

C. O. FOERSTER, JR.
Elsa, TX 78543

ABSTRACT

A documented observation of the least squares fit of a Gompertz Curve to the growth data of an avocado graft is given together with an algorithm for the least squares fit of the Gompertz Curve to any data.

The graph of the height of a plant plotted as a function of time yields a characteristic sigmoid curve known as the growth curve for a plant. Observations of the growth of several species of plants and bacterial colonies are known to fit the logistics curve well (1). A growth curve that is not as well known is the Gompertz Curve, of the form

$$y = ka^{b^x} \text{ with parameters k, a, and b, and } 0 < b < 1.$$

The purpose of this paper is two fold: first, a documented observation is given of a Gompertz Curve that closely fits the growth curve for an avocado graft, and secondly, a numerical routine is given that can be used to fit the Gompertz Curve to other growth data.

MATERIALS AND METHODS

The data was collected by the junior author from a graft on an avocado tree in Elsa, Texas made on July 1, 1971.

The collected data points (x_i, y_i), $i = 1, 2, \ldots, N$ form the best fit to the Gompertz Curve in the least squares sense if the parameters k, a, and b simultaneously satisfy the three equations

$$\sum_{i=1}^{N} \ln y_i = N \ln k + \left[\sum_{i=1}^{N} b^{x_i}\right] \ln a \qquad (1)$$

$$\sum_{i=1}^{N} b^{x_i} \ln y_i = \left[\sum_{i=1}^{N} b^{x_i}\right] \ln k + \left[\sum_{i=1}^{N} b^{2x_i}\right] \ln a \qquad (2)$$

$$\sum_{i=1}^{N} x_i b^{x_i} \ln y_i = \left[\sum_{i=1}^{N} x_i b^{x_i}\right] \ln k + \left[\sum_{i=1}^{N} x_i b^{2x_i}\right] \ln a \qquad (3)$$

The numerical routine for solving these three equations consists of assigning a value to b, and solving equations (1) and (2) simultaneously for ln a and ln k. These values of b, ln a, and ln k are substituted into equation (3) as a test for equality. If equality does not hold b is incremented and the procedure is repeated. The authors used a time-sharing APL system that made this procedure easy to implement.

RESULTS AND DISCUSSION

For the 41 data points the routine gives $\ln k = 3.6439$, $\ln a = -1151.3$ $b = 0.5089$.

The data points fit this Gompertz Curve well, yielding a correlation of 0.999. The results are tabulated in Table 1.

The results from Table 1 indicate a close correspondence between the observed data points and the Gompertz Curve, suggesting a possible mathematical model for the growth curve of an avocado graft. Further use of this routine could also establish the validity of the Gompertz Curve for citrus grafts.

LITERATURE CITED

1. Lotka, A. J. 1956. *Elements of mathematical biology.* Dover Press, New York

Table 1. The correspondence between the observed data points and those calculated from the Gompertz curve.

x_i — *days after the graft*	y_i — *observed height in inches of the avocado graft*	y — *calculated height in inches using the Gompertz Curve*
83	0.50	0.56
84	0.75	0.73
85	1.00	0.95
86	1.25	1.21
87	1.50	1.51
88	2.00	1.87
89	2.50	2.28
90	3.00	2.74
91	3.25	3.25
92	3.50	3.82
93	4.00	4.44
94	4.50	5.11
95	5.50	5.83
96	6.50	6.60
97	7.50	7.40

(Continued)

Table 1. Continued

98	8.50	8.24
99	9.50	9.10
100	10.50	10.00
101	11.50	10.91
102	12.50	11.85
103	13.50	12.79
104	14.00	13.74
105	14.50	14.69
106	15.00	15.63
107	16.00	16.58
108	17.00	17.51
109	18.00	18.40
110	19.00	19.30
111	20.00	20.20
112	21.00	21.00
113	22.00	21.90
114	22.50	22.70
115	23.00	23.50
116	24.00	24.20
117	25.00	25.00
118	26.00	25.70
122	30.00	28.20
131	32.50	32.40
133	33.00	33.10
136	33.50	33.90
143	36.00	35.30

Seedbed Soil Salinity and Emergence of Peppers and Carrots Under Sprinkler and Furrow Irrigation

FRANCISCO SALINAS and L. NEAL NAMKEN
Biological Technician and Soil Scientist, respectively, Soil, Water, and Air Sciences, Southern Region, ARS, USDA, Weslaco, TX 78596.

ABSTRACT

Seedbed soil salinity levels were affected by irrigation method during the establishment of sweet peppers and carrots. Soil salinity (EC_E) in the surface 2.5 cm increased from 0.6 to 11.4 mmho/cm during the summer establishment of peppers under furrow irrigation compared with an increase from 0.6 to 3.5 mmho/cm under sprinkler irrigation. Soil salinity below 2.5 cm was the same for both irrigation methods. Sweet pepper populations before thinning were 170,000, 277,000, and 412,000 plants/ha under furrow, 3-5 day sprinkler, and daily sprinkler irrigation treatments, respectively. The EC_E in the surface 2.5 cm of the beds after the establishment of fall carrots under furrow irrigation was 12.3 mmho/cm compared with 5.7 mmho/cm under sprinklers. Carrot populations after stand establishment irrigations were 250,000 and 288,000 plants/ha under furrow and sprinkler irrigation, respectively.

Failure to obtain satisfactory stands of vegetable crops from midsummer through early fall is a common and serious agronomic problem in the Lower Rio Grande Valley. The most frequent causes cited for poor stands are high soil temperatures, damping-off diseases, and the accumulation of salt in the seedbed. In many instances, these three factors are interrelated. The widespread practice of frequent furrow irrigations to control soil temperature during stand establishment may create a favorable environment for the development of damping-off pathogens and may also raise salt concentrations to toxic levels in the seed zone.

All irrigation waters contain salt. Under conditions of high evaporative demand, water moves upward in the soil profile toward the soil surface. When furrow-irrigated seedbeds are flat, evaporation produces a rather uniform salt accumulation over the whole bed surface. Salt accumulation near the plants can be lessened by sloping the surface of the seedbed and planting on the side. The salt concentration effect increases with increasing frequency of furrow irrigation. Salt accumulations at the soil surface during stand establishment may be minimized by using sprinkler irrigation instead of furrow irrigation (2, 3, 5, 6, 7).

Under sprinkler irrigation the salt concentration of the bed surface is reduced by the water passing through the whole surface. Thus, salt can be moved below the seed and a shallow, low salt root zone can be created under sprinkler irrigation (7). Leaching of the raised beds cannot occur under furrow irrigation. A low salt concentration in the seedbed is necessary as even moderately salt tolerant vegetable crops are sensitive to salinity during the germination and seedling stages of plant development (1, 3, 6, 7).

As sprinkler equipment represents a sizeable investment, the decision to convert from furrow to sprinkler irrigation must be based on economic considerations. Some of these considerations could be earlier and more uniform germination and reduced labor for thinning. Higher germination percentages mean fewer seeds are required. If complete germination can be accomplished, crops can be planted to stand and, thereby,, the excess costs of seeds and thinning can be eliminated. No information is presently available for the Rio Grande Valley for comparison of furrow and sprinkler irrigation. The objective of this study was to compare three irrigation management schemes as they affect stand establishment of sweet peppers (*Capsicum annum* L.) and carrots (*Daucus carota* L.).

MATERIALS AND METHODS

The experiments to compare pepper and carrot emergence under furrow and sprinkler irrigation were conducted at Weslaco, Texas, on a Hidalgo sandy clay loam soil. The varieties used were sweet peppers (Grande Rio) and carrots (Long Imperator). These are excellent test crops, since both take a long time for emergence, and require several irrigations for stand establishment. Peppers were planted on July 14, 1970, and carrots were planted on October 14, 1970. Only carrots were grown to maturity.

The experimental layout consisted of nine plots, three in each of three blocks. All plots were 86 m in length. Sprinkler plots contained 8 beds and furrow plots contained 12 beds. Borders were built in the 2-m strips left between irrigation plots and provided a suitable location to lay the sprinkler irrigation pipe.

Double rows 28 cm apart and about 3 cm from the outer shoulder of the beds were planted on beds centered 96 cm apart. A uniform seeding rate of 3.4 kg/ha (there are about 5 times as many carrot seeds per unit weight as there are for peppers) for both carrots and peppers was used.

The sprinkler irrigation equipment consisted of a single stage V-4 Wisconsin centrifugal pump with a 4-inch aluminum mainline and 3-inch laterals. (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.) Number 25 F.B. Rainbird sprinklers with 9/64-inch nozzles were used in a 9.1 x 9.1-m pattern (4). Furrow irrigation water was applied by using 8-inch aluminum gated pipe. The irrigation water contained 700 to 1,000 ppm salt.

The amount of water applied by sprinkling was determined from orifice size, water pressure, and time relationships. Water applied by furrow irrigation was measured by a Hersey-Sparling water meter. No run-off occurred in either system.

Soil salinity data were obtained from electrical conductivity analyses of extracts from saturated soil pastes (9). The soil samples were collected from the center of the beds before the initial irrigation and after emergence. Sampling increments were 0-2.5 cm, 2.5-5.0 cm, 5-10 cm and 10-15 cm for the upper soil profile. Fifteen-cm increments to a depth of 60-cm followed and 30-cm increments, thereafter, to a depth of 182 cm.

A simple split-plot design was utilized to analyze the results (8).

The irrigation methods employed were:

1. Sprinkler irrigation keeping the seedbed surface moist. (Usually daily).
2. Sprinkler irrigation every 3-5 days, depending on weather conditions.
3. Furrow irrigation every 3-5 days, depending on weather conditions.

Sprinkler applications were usually 0.6 to 1.2 cm and furrow applications were usually 5.0 to 7.5 cm per irrigation.

Plant population density counts were initiated shortly after crop emergence in randomly predetermined locations and were continued at those locations at 3 to 7-day intervals up to the thinning date.

RESULTS AND DISCUSSION

The pre-irrigation EC_E means of samples from six locations in each treatment of sweet peppers were 0.6 mmho/cm in the top 15 cm. Salinity gradually increased with depth to a maximum of 1.55 mmho/cm at lower depths (Fig. 1.). The entire area showed little variation in soil salinity. The EC_E of soil extracts from samples taken 4 weeks after planting (August 10) revealed greater seedbed salt accumulations on the furrow irrigated beds. Salt concentration in the top 2.5 cm of the furrow beds was over 3 times greater than the salt concentration in the seedbed surface under either of the sprinkler treatments. The salt distribution below the 30-cm profile depth was similar for all treatments and sampling dates.

Measurements of the salinity level of the seedbed surface following the establishment of carrots planted in October 1970 show that the furrow irrigation technique used resulted in twice as much salt accumulation in the top 2.5 cm of soil as either sprinkler treatments (Fig. 2). The lower profile had essentially the same salinity.

Sweet pepper seedling emergence differences were highly significant between irrigation treatments during the first plant count (Table 1). Peak stands were reached on July 29 when daily sprinkler and 3-5 day sprinkler treatments resulted in 88.5% and 21.0% more plant emergence, respectively, than the furrow irrigation treatment. The daily sprinkler treatment resulted in an earlier as well as a greater stand establishment than the other two treatments. The drastic loss of stand in all treatments

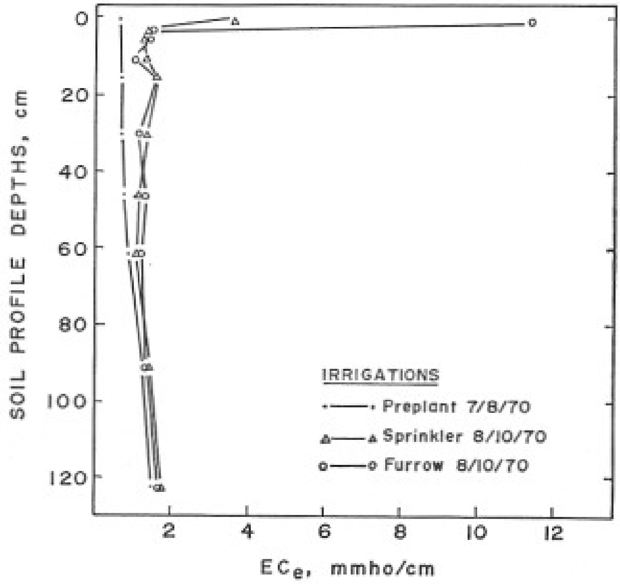


Fig. 1. Salinity distribution in soil profiles before and after the establishment of sweet peppers with sprinkler and furrow irrigation.

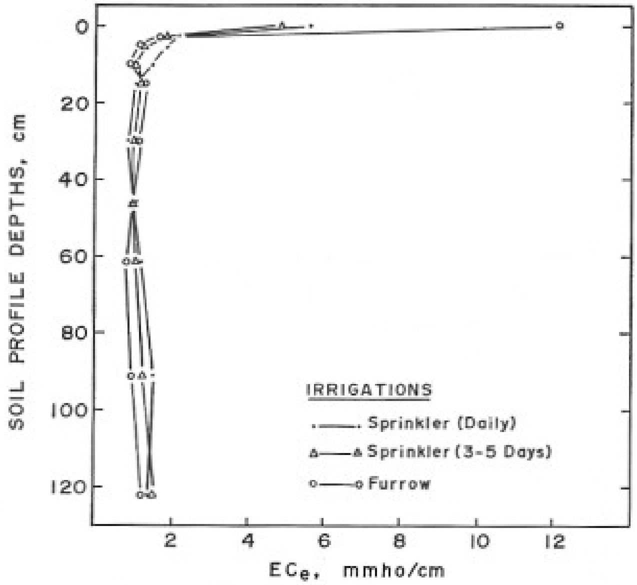


Fig. 2. Salinity distribution in soil profiles after the establishment of carrots with sprinkler and furrow irrigation.

after July 29 is attributed to foreign effects (nematodes and damping-off organisms).

The total water applied to sweet peppers up to final stand counts was 23.5 cm, 21.4 cm, and 43.5 cm for the daily sprinkler, 3-5 day sprinkler, and furrow irrigation treatments, respectively. The rainfall for this period was 4.1 cm. Mean solar radiation for the period was 20% below the long term average of 574 cal/cm²/day. Mean daily temperature for the period was the same as the long term average of 29.2C.

On the last sampling date, carrot seedling emergence for the sprinkler treatments was 14.9% and 11.2% greater than for the furrow irrigation. This increase does not constitute a statistically significant difference (Table 2).

Table 1. Influence of irrigation treatments on pepper seedling emergence at specific dates after planting on July 14, 1970.

Treatments	*7-27-70*	*7-29-70*	*8-10-70*	*8-17-70*
	— — — Number of plants per 1 m of row[1] — — —			
Sprinkler irrigation (Daily)	66.7	72.6	56.2	39.1
Sprinkler irrigation (3-5 days)	39.7	46.6	38.6	26.1
Furrow irrigation (3-5 days)	32.9	38.5	25.4	16.2
Level of significance of "F" test	1%	5%	5%	N.S.
LSD .05	13.3	19.5	19.2	

[1] Mean of 9 sample sites.

Table 2. Influence of irrigation treatments on carrot seedling emergence at specific dates after planting on October 14, 1970.

Treatments	*11-3-70*	*11-5-70*	*11-12-70*	*11-19-70*
	— — — Number of plants per 1 m of row[1] — — —			
Sprinkler irrigation (Daily)	68.7	67.5	68.5	68.5
Sprinkler irrigation (3-5 days)	66.4	65.6	68.5	66.3
Furrow irrigation	63.1	62.0	62.7	59.6
Level of significance of "F" test	— — — — — N. S. — — — — —			

[1] Mean of 9 sample sites.

The total water applied to carrots up to final stand counts was 10.7 cm, 7.5 cm, and 18.6 cm for the daily sprinkler, 3-5 day sprinkler, and furrow irrigation treatments, respectively. There was no rainfall during this crop season. Mean solar radiation for the period was 23% below the long term average of 328 cal/cm^2/day. Mean daily temperature for the period was one degree below the long term average of 21.6C.

CONCLUSIONS

Pepper and carrot plant emergence under sprinkler irrigation was as much as 58.7% and 15.2% greater, respectively, than emergence under furrow irrigation. Emergence was not significantly different among treatments for fall-seeded carrot as it was for summer-seeded pepper, possibly because germination conditions differed so between October and July.

Soil salinity of the seedbed surface reached concentrations as much as 3 times greater with the furrow technique than with the sprinkler method during the establishment of peppers and carrots. The migration of water into furrow-irrigated seedbeds and subsequent evaporation from the bed surface resulted in salt accumulation that reduced plant emergence of peppers in summer. In contrast, water applied directly to seedbed surface with sprinklers leached salts downward, and provided a more favorable seedbed for vegetable establishment.

Growers should use sprinklers especially where seedbed soil salinity is usually a problem. Also, if irrigation water is metered, sprinklers will definitely save water during the establishment of the crop.

LITERATURE CITED

1. Ayers, A. D., and H. E. Hayward. 1948. A method for measuring the effect of soil salinity on seed germination with observations on several crop plants. Soil Sci. Soc. Amer. Proc. 13:224-226.

2. Bernstein, Leon, and Milton Fireman. 1957. Laboratory studies on salt distribution in furrow-irrigated soil with special reference to the preemergence period. Soil Sci. 83:249-263.

3. Bernstein, Leon, A. J. MacKenzie, and B. A. Krantz. 1955. The interaction of salinity and planting practice on the germination of irrigated row crops. Soil Sci. Soc. Amer. Proc. 19:240-243.

4. Christiansen, J. E. 1942. Irrigation by sprinkling. Univ. of California, Agr. Exp. Sta. Bull. 670. 124 p.

5. Haise, Howard R. 1948. Flow pattern studies in irrigated coarse-textured soils. Soil Sci. Soc. Amer. Proc. 13:83-89.

6. Reeve, Ronald C., and Milton Fireman. 1967. Salt problems in relation to irrigation, p. 893-1008. *In* R. M. Hagen, H. R. Haise, and T. W. Edminster, [ed.] Irrigation of Agricultural Lands. Agron. Monograph No. 11. Amer. Soc. Agron. Publishers, Madison, Wis.

7. Robinson, Frank E., and O. D. McCoy. 1967. Population, growth rate, and maturity of vegetable crops in relation to soil salinity and texture under sprinkler and furrow irrigation. Agron. Jour. 59:178-181.

8. Steel, R. G. D., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc., New York. 481 p.

9. U. S. Salinity Lab. Staff. 1954. Diagnosis and improvement of saline and alkali soils. U. S. Dept. Agr. Handbook 60.

Flooding Effects on Light Reflectance, Transmittance, and Absorptance of Cotton (*Gossypium hirsutum*) Leaves

R. R. RODRIGUEZ and H. W. GAUSMAN
Physical Science Technician and Plant Physiologist, respectively,
Soil, Water, and Air Sciences, Southern Region, ARS, USDA,
Weslaco, TX 78596.

ABSTRACT

Leaves from cotton plants flooded for 14 days became yellow (chlorophyll deficient), and their light reflectance was increased in the visible wavelength region (500 to 750 nm) compared with the green leaves of nonflooded plants. This change in reflectance might provide a basis for the remote sensing (aerial photography or multispectral scanner) determination of flood damage to crops after heavy rains.

Considerable research has been conducted on factors affecting reflectance, transmittance, and absorptance of leaves (2,3,7,9), but effects of flooding the soil with water in which plants are growing have not been considered.

This paper reports research conducted to determine if flooding a soil mixture with water in which cotton plants were growing affected light reflectance, transmittance, and absorptance of leaves compared with leaves from nonflooded (normal) plants.

MATERIALS AND METHODS

Five cotton seeds (Stoneville 7) were planted per 4.5-liter plastic pot containing a sandy clay loam soil mixed with a horticulture conditioner—Perlite (0.02% by weight)—and a 10-25-5 fertilizer to give an equivalent rate of 60 lb of N per acre (67.2 kg/ha). (Trade and company names are included for the convenience of the reader and do not imply endorsement or preferential treatment by the U.S. Department of Agriculture.) After emergence, plants were thinned to two per pot. The experiment was conducted in a greenhouse during January 1972.

The experimental design was a randomized complete block with 10 replications of two treatments consisting of nonflooded (normal) and flooded cotton plants.

The first and second true leaves became macroscopically visible 7 and 10 days after plant emergence, respectively. Flooding was begun one day after the second true leaves became visible, and the soil was kept saturated for 2 weeks before spectrophotometric measurements were made. Normal plants were watered every Monday and Friday with 250 ml of water per pot.

Twenty-five days after plant emergence, second true leaves were detached from normal and flooded plants and immediately wrapped in Glad Wrap to minimize moisture loss. Before spectrophotometric measurements were made in the laboratory, leaves were wiped with a damp cloth to remove surface contaminants.

A Beckman Model DK-2A spectrophotometer equipped with a reflectance attachment was used to measure reflectance and transmittance on upper (adaxial) leaf surfaces over the 500 to 2500-nm wavelength interval (WLI). Data were corrected to give absolute radiometric data (1). Absorptance was calculated as: Absorptance = 100 − (reflectance + transmittance).

Leaf thickness was measured with a linear displacement transducer and digital voltmeter (4). Percent leaf water content was determined on an oven dry-weight basis by drying at 68C for 72 hr and cooling in a desiccator before final weighing. Leaf area was determined with a Hayashi Denko Automatic Area Meter, Model AAM-5. (Yen Enterprises, Inc., Terminal Tower Building, Public Square, Cleveland, Ohio 44113.)

Tissue pieces, taken near the center of leaves approximately one-half inch (1.27 cm) on either side of the midrib, were fixed in formalin-acetic acid-alcohol (FAA); dehydrated with tertiary butanol; embedded in paraffin; stained with safranin-fast green (5); microtomed at a thickness of 12 and 10 u for flooded and non-flooded plants, respectively; and photographed with a Zeiss Standard Universal photo-microscope.

Data were subjected to analysis of variance (8).

RESULTS AND DISCUSSION

The growth of a cotton plant in a water-saturated soil is poor because of the development of toxic substances, insufficient oxygen for respiration, and the lack of nitrate formation (6). Therefore, the appearance and size of leaves from normal and flooded plants differed. Leaves from flooded plants had one lobe, were yellow (chlorophyll deficient), and were 14.5 cm^2 in area; whereas leaves from normal plants had three lobes, were green, and were 17.8 cm^2 in area.

Flooding did not significantly affect the percent water content or thickness of leaves. Leaves from flooded plants had an average of 78.5 compared with 78.0% water for normal leaves. Leaves from flooded plants had an average thickness of 0.136 compared with 0.132 mm for normal leaves.

The leaf mesophyll from a normal plant had the same cellular structure as the leaf mesophyll from a flooded plant. However, the normal leaf mesophyll had more chloroplasts in its palisade cells than the leaf mesophyll from a flooded plant.

Reflectance, transmittance, and absorptance (Fig. 1, 2, and 3, re-

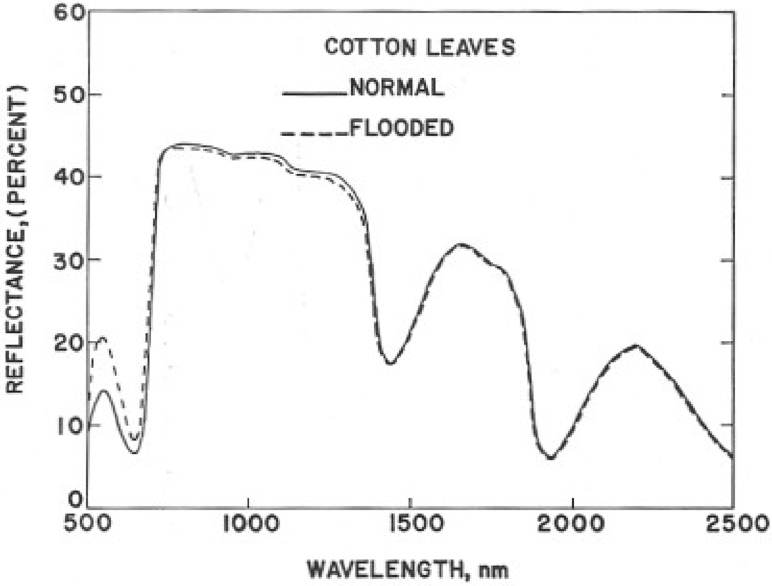


Fig. 1. Percent reflectance of leaves from normal and flooded cotton plants over the 500 to 2500-nm wavelength interval.

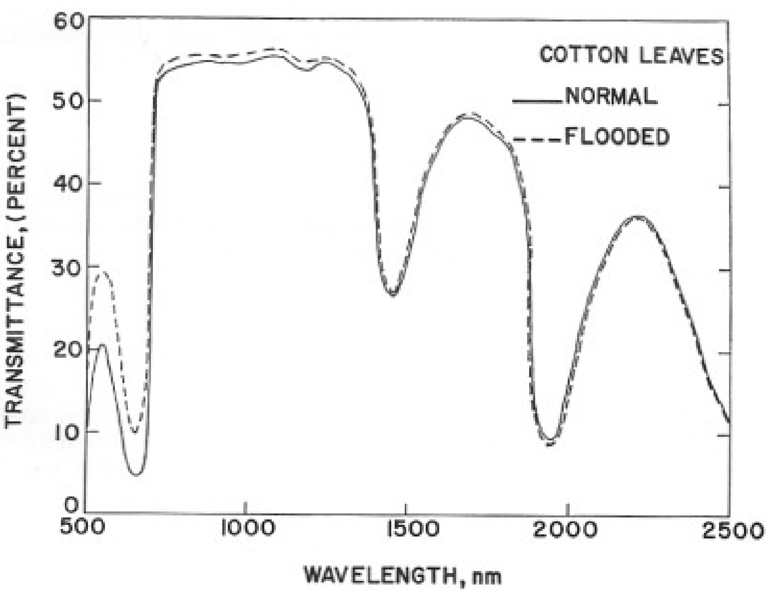


Fig. 2. Percent transmittance of leaves from normal and flooded cotton plants over the 500 to 2500-nm wavelength interval.

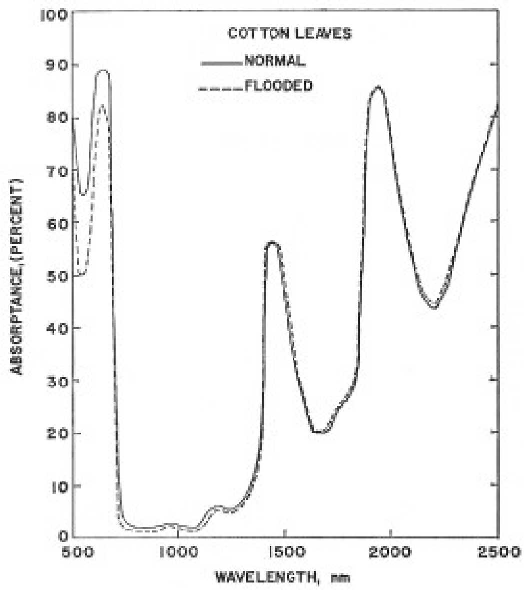


Fig. 3. Percent absorptance of leaves from normal and flooded cotton plants over the 500 to 2500-nm wavelength interval.

spectively) in the infrared region (750 to 1350 nm) were essentially unaffected by flooding. Differences between leaves of flooded and normal plants were statistically significant for reflectance, transmittance, and absorptance in the visible region (500 to 750 nm). Leaves of flooded plants had higher reflectance and transmittance than normal leaves. Reflectance was 17.4 and 13.2% and transmittance was 23.7 and 16.4% at the 550-nm wavelength for leaves of flooded and normal plants, respectively. The leaves from flooded plants had lower absorptance (58.9%) than leaves from normal plants (70.4%).

Yellow (chlorophyll deficient) leaves from flooded cotton plants have higher light reflectance in the visible region than green leaves from normal plants. This change in reflectance might provide a basis for the remote sensing (aerial photography or multispectral scanner) determination of flood damage to cotton plants after heavy rains. Flood damage might also be determined on vegetable and fruit crops with remote sensing equipment and techniques because many kinds of plants react essentially the same as cotton to too much water.

ACKNOWLEDGMENT

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

LITERATURE CITED

1. Allen, W. A., and A. J. Richardson. 1971. Calibration of a laboratory spectrophotometer for specular light by means of stacked glass plates. Rev. Sci. Instruments 42:1813-1817.

2. Billings, W. D., and R. J. Morris. 1951. Reflection of visible and infrared radiation from leaves of different ecological groups. Amer. J. Bot. 38:327-331.

3. Gausman, H. W., W. A. Allen, R. Cardenas, and A. J. Richardson. 1970. Relation of light reflectance to histological and physical evaluations of cotton leaf maturity. Appl. Opt. 9: 545-552.

4. Heilman, M. D., C. L. Gonzalez, W. A. Swanson, and W. J. Rippert. 1968. Adaptation of a linear transducer for measuring leaf thickness. Agron. J. 60:578-579.

5. Jensen, W. A. 1962. Botanical histochemistry. W. H. Freeman & Co., San Francisco, Ca. 408 p.

6. Millar, C. E. 1955. Soil fertility. John Wiley & Sons, Inc., New York. 436 p.

7. Shull, C. A. 1929. A spectrophotometric study of reflection of light from leaf surfaces. Bot. Gaz. 87:583-607.

8. Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York. 481 p.

9. Thomas, J. R., C. L. Wiegand, and V. I. Myers. 1967. Reflectance of cotton leaves and its relation to yield. Agron. J. 59:551-554.

Light Reflectance of *Peperomia* Chloroplasts

Harold W. Gausman
Plant Physiologist, Soil, Water, and Air Sciences,
Southern Region, ARS, USDA, Weslaco, Texas 78596.

ABSTRACT

This study tested the premise that chloroplasts reflect near-infrared light (750 to 1350 nm). Light over the 370 to 1100-nm wavelength interval was impinged on *Peperomia obtusifolia* chloroplasts, and reflectance was measured with a Leitz microspectrophotometer. Reflectance increased from 0.6% at 470 nm to 13.5% at 600 nm and then leveled off for the 600 to 1100-nm wavelength interval to form a plateau lying between 12.7% at the 900-nm wavelength and 15% at the 1100-nm wavelength. Results show that *P. obtusifolia* chloroplasts reflect both near-infrared light (750 to 1100 nm) and visible light (470 to 750 nm).

Near-infrared light reflectance (750 to 1350 nm) is usually increased by an increase in number of air spaces in leaf mesophylls (1,2,3,7,8). It has also been postulated (9) and demonstrated (4,5) that refractive index discontinuities in leaves other than cell wall-air interfaces reflect near-infrared light.

Research reported here tested the premise that chloroplasts of *Peperomia obtusifolia* reflect near-infrared light.

MATERIALS AND METHODS

A Leitz microspectrophotometer was used for reflectance measurements (MPV Microscope Photometer, Instructions for Assembly and Operation, Ernst Leitz, Wetzlar, Germany). (Company and trade names are included for the benefit of the reader and do not imply an endorsement of or preference for the product listed by the U.S. Department of Agriculture.)

Light over the 370 to 1100-nm wavelength interval is transmitted through a field diaphragm and objective on a monochromator into an illuminator mounted on the microscope tube. A beam splitter or prism arrangement directs the light through the objective towards the specimen. The light reflected by the specimen is transmitted by the objective and proceeds through the microscope tube towards the photo detector. A four-leaf measuring diaphragm in the light beam path can be varied in either the X or Y direction so that object detail to be measured is masked in the image plane of the microscope. By stopping down the field diaphragm, the illuminated field in the object plane is narrowed so that it just surrounds the measuring field.

The reflected beam of light reaches the cathode of the photomultiplier. When the dark current noise component of the photomultiplier measuring device is adequately reduced with a "suppression" voltage, the anode current of the photomultiplier is proportional to the reflected light intensity. Signals are indicated by an ammeter (galvanometer), and they are recorded by an X-Y strip chart recorder.

A 25/0.65 achromatic oil or water immersion objective (oil was used in this study) transmitted reflected light from the object of the specimen upward in the monocular microscope tube with a 10X eyepiece at its apex. The objective used is designed for reflected but not for transmitted light.

Measurements were made in a temperature-controlled room at 22 C with subdued light intensity near the microspectrophotometer.

Peperomia obtusifolia leaves were used to provide large chloroplasts (10 to 20 u diameter). An extraction medium (6) developed for maximum preservation of organelles in homogenates was used. The medium contained 2.5 g Ficoll, 5 g Dextran-40, and 10 mg bovine serum albumin/100 ml medium; 0.025 M Tris-HC1 buffer, pH 7.6; and 0.25 M sucrose as the osmotic agent. The upper epidermis of the leaf was stripped off, a few drops of extracting medium were placed on the exposed cells, and the mesophyll region was cut several times with a razor blade. The cell-free extract was collected by a capillary pipette, transferred to a slide, and covered with a cover slip.

The sequence of phases from the glass slide, on which the chloroplasts were mounted, to the objective was: chloroplasts in extracting medium–No. 1 cover slip–immersion oil (refractive index 1.1515). A 17.5% reflectance standard was used for calculation of reflectance power. The sequence of phases from the surface of the reflectance standard to the objective was: oil–slide–liquid–No. 1 cover slip–oil. Immersion oil and glass cover slips have essentially the same refractive indices.

Reflecting power R of a specimen was calculated as

$$R = \frac{I}{I_0} R_0$$

where I = reflectance of a specimen, R_0 = reflecting power (17.5%) of the standard used, and I_0 = reflectance of the standard.

Measurements on chloroplasts and the reflectance standard were replicated 15 times. Measuring diaphragm sizes were 13.5 x 15 u and 10 x 11 u for 4 and 11 replications, respectively.

RESULTS AND DISCUSSION

Reflectance was measured over the 370 to 1100-nm wavelength interval, but *P. obtusifolia* chloroplasts only increased reflectance (reflecting power) over the 470 to 1100-nm wavelength interval. Results are charted in Fig. 1 as an average of 15 replications. Standard errors are

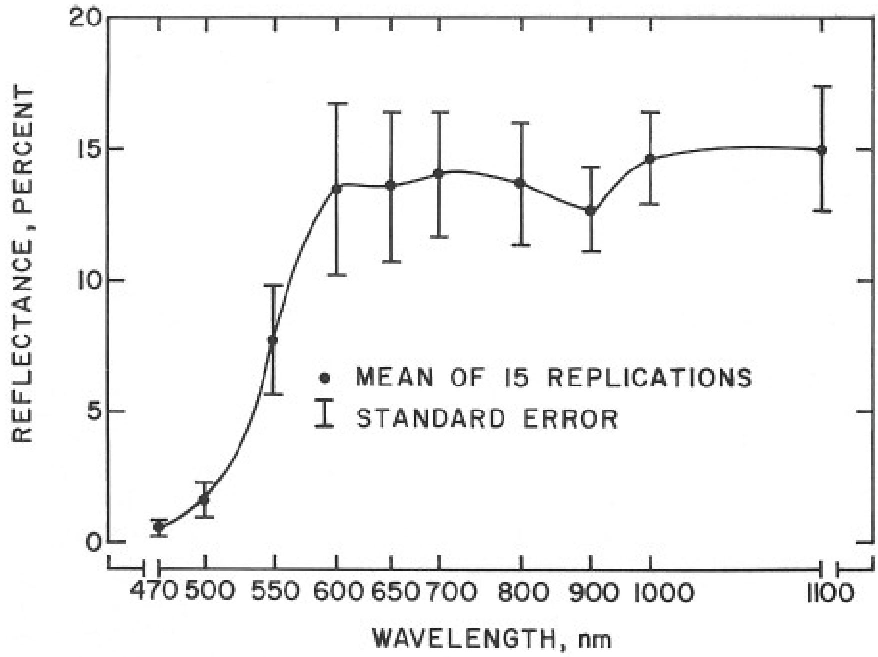


Fig. 1. Reflectance (reflecting power) of *Peperomia obtusifolia* chloroplasts over the 470 to 1100-nm wavelength interval.

shown for each wavelength at which reflectance measurements were recorded.

Reflectance increased from 0.6% at 470 nm to 13.5% for 600 nm and then leveled off for the 600 to 1100-nm wavelength interval to form a plateau lying between 12.7% at the 900-nm wavelength and 15% at the 1100-nm wavelength. The large standard errors obtained may have resulted from differences in size among the 15 chloroplasts measured because the diaphragm size was varied to impinge the light beam only on the chloroplasts.

Chloroplasts contain chlorophyll, but the absorptance of light by chlorophyll is not evident (Fig. 1). Apparently, the large chloroplasts that were selected for reflectance measurements were low in chlorophyll content. The decreased reflectance shown at the 900-nm wavelength was undoubtedly caused by tissue water absorption.

Results show that *P. obtusifolia* chloroplasts reflect both near-infrared light (750 to 1100 nm) and visible light (470 to 750 nm). This light reflectance by chloroplasts contributes to the reflectance from plant leaves that can be detected by remote sensors mounted in aircraft and spacecraft.

ACKNOWLEDGEMENT

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

LITERATURE CITED

1. Allen, W. A., H. W. Gausman, A. J. Richardson, and R. Cardenas. 1971. Water and air changes in grapefruit, corn, and cotton leaves with maturation. Agron. J. 63:392-394.

2. Gates, D. M., H. J. Keegan, J. C. Schleter, and V. R. Weidner. 1965. Spectral properties of plants. Appl. Opt. 4:11-20.

3. Gausman, H. W., W. A. Allen, V. I. Myers, and R. Cardenas. 1969. Reflectance and internal structure of cotton leaves, *Gossypium hirsutum L.* Agron. J. 61:374-376.

4. Gausman, H. W. 1973. Photomicrographic record of light reflected at 850 nanometers by cellular constitutents of *Zebrina* leaf epidermis. Agron. J. 65: 504-505.

5. Gausman, H. W. 1973. Light reflectance of leaf constituents. *In* F. Shahrokhi (ed.), Remote Sensing of Earth Resources, The University of Tennessee Space Institute, Tullahoma, 2: (in press).

6. Hongladaron, T., and S. I. Honda. 1966. Reversible swelling and contraction of isolated spinach chloroplasts. Plant Physiol. 41:1686-1694.

7. Sinclair, T. R. Pathway of solar radiation through leaves. M.S. Thesis, Purdue University Library, Lafayette, Indiana.

8. Willstatter, R., and A. Stoll. 1918. Untersuchungen uber die Assimilation der Kohlensaure, Julius Springer, Berlin.

9. Woolley, J. T. 1971. Reflectance and transmittance of light by leaves. Plant Physiol. 47:656-662.

Editorial Guidelines for Manuscripts

Submit two type copies (one ribbon copy) of manuscript; double-spaced, including tables, captions, and legends; top, bottom and side margins should be at least one inch. Last word at bottom of page should be a whole word, *don't* carry part of last word to next page.

Subjects: Previously unpublished scientific research and observations, review articles, articles on new methods or techniques, reports of new problems or pests, evaluations of market situations, releases of new varieties, etc. are acceptable for publication. Popularized or new versions of previously published information are not acceptable. Papers should be relevant to some aspect of horticulture in the Lower Rio Grande Valley, but the work need not have been carried out in this area. Manuscripts dealing with non-horticultural crops are acceptable if they have some application to horticultural science.

Title: Capitalize first letter only of important words. Keep title brief. It should reflect important aspects on the article.

Byline: Author's name follows title. This is followed by the author's affiliation (title and institution) and institutional address with zip code. Acknowledgements are to be placed at end of article, but ahead of Literature Cited. *No footnotes.* Supplementary information should be included in the text and may be enclosed in parentheses.

Abstract: An abstract written by the author follows the institutional address, separate with space. The abstract should be brief, concise and informative. Key words and phrases in article should be used to facilitate information retrival. Additional key words may be used.

Use a solid line to separate abstract from body of manuscript, with two to four spaces above and below the line.

Text: Introductory statements (No Introduction heading) should give the background and objectives of the research work reported or purpose of the article.

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

Names of proprietary substances, materials and special apparatus should be followed by the name and address of the manufacturer in parentheses.

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

Tables and Figures. Indicate in margin of the manuscript where each table and figure should appear. Captions should adequately describe contents so that tables and figures are understandable when considered apart from the text.

Each table should be typed on a separate page. Don't crowd tables with excess columns.

Figures should be unmounted. Type figure *(Fig. 1)* and legend for each figure on a separate page. On back of unmounted illustration, photograph or graph, write figure number, title of paper and author with a soft lead pencil. Avoid making creases in picture or illustration with pencil.

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

Either the metric or English system of measurements may be used. The two systems should not be mixed, e.g. as 28 g Xeno to 25 gal water. If metric or English system is used, equivalent measures in the other system may be indicated in parentheses, e.g. 908 g/500 liters (1.52 lb/100 gal).

When in doubt as to style or acceptable usage consult STYLE MANUAL for BIOLOGICAL JOURNALS. Conference of Biological Editors, AIBS. Literature citations should be in the form suggested in the STYLE MANUAL.

One author of the paper should be a member of the RGV Horticultural Society.

Authors are responsible for the accuracy, quality, content and readability of papers published in the Journal. Well written papers, which contain new information, fresh ideas or good subject material, reflect credit on both the author and the institution he represents.

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

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