JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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Aims and Objectives of the Society

The purpose of the Rio Grande Valley Horticultural Society is the advancement and development of horticulture 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 monthly meetings subjects of interest are presented by specialists in their fields. 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 20 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 barbecue 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 $4.00, 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.

COVER: This well-landscaped Valley home is outstanding in the use of ornamentals which contributes much to the pleasure of home-ownership.
(Photo courtesy of Jack Marshall)

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Program of the Twentieth Annual
Institute of the Society
January 25, 1966

MORNING PROGRAM

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USDA, ARS, CRD, Weslaco

Blossom End Rot of Tomatoes .... Dr. C. J. Gerard, Soil Physicist
Texas A&M U., Texas Agr. Exp. Sta., R.E.C. Weslaco

Present Status of Mechanical Harvesting of
Fruit and Vegetable Crops .... Dr. Jordan H. Levin, Leader
Fruit and Vegetable Harvesting Investigations; USDA,
ARS, AERD, (Mich. Univ.) East Lansing, Michigan

Recent Developments in Citrus Production .... Dr. R. A. Hensz, Director
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Recent Developments in
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Texas A&M U., Texas Agr .Exp. Sta., REC, Weslaco

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Horticultural and Special Crops Branch, Marketing
Economics Division, USDA, ERS, Washington, D. C.

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Texas Water Development Board, Austin, Texas

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USDA, ARS, CRD, Weslaco

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Vegetable Processing .... Dr. F. P. Griffiths, Chemist in Charge
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SAM D. TAYLOE,

Recipient of the Arthur T. Potts Award for 1966

Sam D. Tayloe of Monte Alto was named recipient of the Arthur T. Potts award for 1966 at the Rio Grande Valley Horticultural Society's 20th Annual Meeting.

He received the award largely as a result of his co-operation, as manager of Rio Farms, with various vegetable and citrus research organizations. He was largely responsible for land and other facilities at Rio Farms being placed at disposition of state and federal agencies such as the Texas Agricultural Experiment Station, Texas Department of Agriculture, USDA, and others.

Among projects now under way at Rio Farms are cold hardiness studies; rootstock investigations to determine what tristeza resistant rootstock is adaptable to Valley conditions, the effect of various levels of salt on citrus rootstocks, indexing of commercial fruit conditions for various virus diseases and assistance with development of nucellar citrus varieties.

Most recently inaugurated have been plant breeding studies for the purpose of growing, testing and proving many thousands of hand-polinated hybrids. He has co-operated with various vegetable growing and marketing tests.

Mr. Tayloe has been a member of the Vegetable Research and Marketing Advisory Committee of the USDA for 11 years. He is a member of the Century Club of Texas A. and M. University consisting of outstanding business leaders throughout Texas. He also was responsible for development and establishment of the True Taste Corporation in Monte Alto.

Mr. Tayloe was born in Clarkesville, Texas in Red River County where he graduated from high school. He later attended John Tarleton College and Texas A. and M.

He went to work for Texas Rural Communities in 1935 and this developed into the Farmers Home Administration for which he became rural supervisor and then district supervisor which position he gave up in 1943 to become manager of Rio Farms.

ADDRESS OF WELCOME

20th Annual Horticultural Society Institute

It is indeed a pleasure to welcome you to the 20th annual Rio Grande Valley Horticultural Society Institute. This is an event which we have come to look forward to during the years for a *number* of reasons. We get to see old friends from other areas of the Valley and to meet new friends from among our guests. It is also a time when we are privileged to get acquainted with some of the foremost specialists in their respective fields who are here to appear on our program. The Arthur T. Potts Award is always a highlight of our meeting when we see recognition given to men who have done much for horticulture and for our Society. The most *important* reason we are here, however, is to be brought up-to-date on the latest developments in areas that are affecting—or will in the FUTURE affect—agritulture here in the Valley. In a region where the economy is so vitally dependent on agricultural products, as is our Valley, it is imperative that we keep well informed of our problems and what can be done in resolving them. In keeping with this aim, the programs of our Institute are planned to include discussions of the most timely matters facing us now.

In looking over today's program, we see topics that will be of interest to everyone engaged in any field of horticulture. From a production standpoint, there are discussions of new varieties and recent developments in both citrus and vegetables. Also included are talks on production problems of tomatoes and nematodes that probably do more damage to our crops than any of us realize. The rapid development of herbicides to aid in reducing labor costs and eliminating competition to our growing crops from weeds almost staggers the imagination!

These improvements in *production* increase our YIELDS and reduce the LABOR needed, but *how do we get all of this produce harvested?* Perhaps Dr. Levin can offer us some hope in this field. After the harvest come the problems of processing and sales. This is the most *critical* area in the whole cycle. It is of little consequence how MUCH we produce or how EFFICIENTLY it is produced if we are unable to SELL at a profit. Processing and advertising are included in the program, and Dr. Powell will give us some insight into the broad field of marketing from the farm to the ultimate consumer.

Without adequate water to insure irrigation, processing and related industries, AND domestic uses, all the aforementioned items are academic, so we are anxious to hear what Mr. Moore has to bring us on THIS vital matter.

Let me urge as many as can to bring your wives—and families—to the evening session of the Institute. This promises to be both informative and entertaining with Dr. Bailey's talk on ornamentals for the home, and Dr. Corns' travelogue of the Caribbean area. I promise that you will not be disappointed in this program.

Your presence here is indicative of your interest in horticulture, and if you are *not* a member of the Horticultural Society you are invited to become one today. It is through the support of our members and friends that this Institute and the many enlightening programs on horticulture throughout the year are possible. If you would like to be a part of this, see the young ladies at the desks in the rear of the room and they will be glad to take your membership. Dues are $4 a year, including the JOURNAL which, within itself, is worth the price of membership.

I would like to take this opportunity to thank Dr. Henz, and his staff here at the A&I Citrus Center, for being such gracious hosts—not only for this Institute but for our regular meetings throughout the year. We want to acknowledge the work which Dr. Sleeth and his committee, A. V. Schull and Frank Rider, have done in arranging this fine program today—AND—our sincere gratitude is extended to the MANY others who have worked so diligently to make this Institute a success.

C. E. DAVIDSON, *President*

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Brownsville, Texas

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CITRUS AND SUBTROPICAL FRUIT SECTION

Ways of Modifying Grower Returns for Horticultural Crops

Presented by LEVI A. POWELL, SR.[1]

Since man first engaged in the compromising game of exchange as a choice over acquisition by might to satisfy his physical needs, I daresay, that the kind of issue you have posed has occupied his thoughts at least on par with war, sin and sex. This is understandable, for short of satiation of man's needs for goods and services, exchange will continue to be a central focus of interest in his daily existence.

Exchange involves a sort of contest despite the oversimplified doctrine that participants willingly entering into such an agreement all benefit. Therefore, no need for skepticism, all should be reasonably happy. Alas, this ignores the "real world" facts that willingness can be quite spongy and yielding and the disposition to make concessions much greater for one party to a trade than for the other. Now this is in agreement with the proposition that free exchange yields mutual benefits. Nonetheless, after the bargain is sealed, parties thereto frequently discover that they settled for less than they otherwise might have gotten. Here I draw on recent experience. How often have we heard someone claim that he could have gotten $50 more for his old "clunker," or is the word "dog" now?, on trade-in had he bargained more persistently. The point is simply this, the range between the highest price that a buyer is willing to pay and the lowest a seller is willing to accept may accommodate a number of so-called satisfactory prices in harmony with the doctrine.

The arrival at or discovery of price through the process of exchange in the complex market place of today remains much of a mystery. People are fascinated by it, marvel at it, knock it, study it but still don't really quite understand it. We have a neat supply and demand theory that we pretent is simple and perfectly understandable to everyone but it seems at times to be only an indirect manifestation and does not bore into and reveal the real substance of the process of pricing. If I may exaggerate, not much more than a thermometer explains the scientific mysteries of temperature fluctuations.

In less-complicated days, our economy flourished on free-market pricing. The free-wheeling give and take of supply and demand held sway in most of the land. But as the economy became more complex and imbalances of economic power were, or were thought to be, iden-

[1] Acting Chief, Horticultural and Special Crops Branch, MED, at the 20th Annual Horticultural Institute, January 25, 1966 at Weslaco, Texas.

tifiable, there were movements to limit the excessive influence some were able to exert in the market place.

Although prior to the Civil War the United States largely had but one voice, that of the agricultural majority, afterward rural America became one of the fountainheads of economic dissent. The proposed retirement of the "greenbacks" in the 1870's was one of the first major issues against which farmers diligently protested. Retirement of the $433 million of paper money issued to finance the "Northern" war would have brought about serious deflationary pressures and hence would have been detrimental to the interest of farmers in their role as debtors already suffering under the burden of falling prices. Failing to carry the greenback issue, farmers later turned their support to free silver. They reasoned that if the free coinage of silver at the ratio of 16 ounces of silver to 1 of gold could be restored, new silver strikes could produce so much of the metal that prices would rise to a profitable level. Theirs was not an interest in any particular monetary theory per se, but they did want higher prices and the implementation of a national policy that achieved this.

About this same time, farmers were engaged in a lively fracas with the railroads. A farm paper correspondent is said to have written in 1890, "There are three great crops raised in Nebraska. One is a crop of corn, one a crop of freight rates, and one a crop of interest. One is produced by the farmers who by sweat and toil farm the land. The other two are produced by men who sit in their offices and behind their bank counters and farm the farmers." (1)[2] To strengthen their contest with the railroads, farmers became affiliated with the organization known as the Patrons of Husbandry, or the Grange. Founded in Washington, D. C., in 1867 as a sort of social and educational farmers' club, the order was changed into a politically active organization with a membership estimated by one author at about 1½ million by 1874. (1) The early efforts of the Grange ultimately led to the passage of the Interstate Commerce Act and resulted in subsequent regulation of freight rates. The Sherman Anti-Trust Act may be credited in part as another legislative triumph of agricultural interest of the era.

The later years of the 1800's also witnessed the upsurge of another great movement – strong support of cooperatives. Momentum initially provided this approach to improving the farmer's position by the Grange, Farmers Alliance, and other early farmer organizations still endures. Their efforts eventually resulted in the enactment of legislation recognizing and establishing the legal identity of co-ops as agencies privileged to bargain, sell, and buy for farmers. In fact, the Federal Farm Board set up in 1929 to cope with the agricultural price collapse at the beginning of the "great" depression was tailored according to cooperative precepts. Its functions were to encourage cooperative

[2] Numbers in parentheses refer to citations at end of paper.

marketing and to work for price stabilization through attempts to finance crop storage. As our recollections tell us, this effort, although helpful, was inadequate to forestall the the ravages of the depression. Successive enabling legislation was passed beginning in 1933 and ending with the last session of Congress dealing with the notions first of price and then of income parity, marketing quotas, acreage allotments, marketing orders and agreements, special food purchase and distribution programs and compensatory payments – all in some fashion related to improving the income position of farmers.

Although the militancy of farm groups may have tended to move inversely to the price level for farm products on occasion, their determination against low prices and high costs have never been entirely dormant. Support of farm organizations devoted to the economic interest of farmers persisted even during the span of years between the turn of the century and World War I – dubbed the golden era of American agriculture by some agricultural economists.

This quick chronological span of the last 100 years of agricultural history is a convenient vehicle for reminding us of the constancy of a familiar theme; namely, the self-same subject that has been proposed for discussion today. That is, the search for alternative means of improving income, lowering costs and otherwise improving the terms of trade for agriculture. Strategies have tended to change in conformity with what is possible and publicly desirable but basic goals in terms of income improvement have retained many elemental similarities. Let us review avenues theoretically open to farmers for achieving these goals.

First, it is convenient to recognize that in attempting to enhance their share of, say, the total final outlay for agricultural products, farmers are really trying to alter a given economic distributive process. That is to say, they are saying the economic mechanism for the given marketing system is not allocating to them what they consider to be a "fair" share or value for goods and services rendered. This leads to the question of the type of allocative process desired and the need for consideration of the different set of conditions proposed systems would impose upon the industry. Finally comes recognition that changes require public sanction and must be engineered through the legal process in our democratic society.

In a broad sense, all economic distributive systems are shaped by three behavioral processes (a) free choice individual action, (b) group action, and (c) often from some preferred admixture of individual and group actions. Allocative processes thus contrived carry with them rules that govern their workability. Industry members must agree upon and learn to live with such rules to achieve desired results. One further point, these processes take on two forms—those external and those internal to the industry concerned. External allocation has to do with how the industry goes about disposing of and distributing its produce among buyers and the resulting share of value that is passed back in total to the producers. Internal allocation has to do with the way these gross proceeds are distributed among the industry producers. But this is not all. Internal allocation, as we shall see, has to do with dispersion of net realizations among producers also.

Because fruits and vegetables are in line with your interest, I will limit my discussion to techniques open to these industries. Too much classification can become wearisome but it is nonetheless a handy way of looking at procedures producers may adopt for affecting income shares allocated them by the market.

The first that comes to mind is the modernized free-enterprise system preferred by some industries. I say modernized because the industry operates within an economic situation constrained by accepted viewpoints, private and public, and by certain legal rules, e.g., those against unfair competition, etc., that the public has seen fit to impose from time to time. This system is the recommended choice of those whose economic persuasion is micro or the theory of the individual business. And certainly it is not to be scoffed at. But you ask how can a single firm, if it is one of many, affect price or receive a higher price than others and gain a larger share of the consumer's dollar? The answer is that it cannot by affecting price, but it well might by increasing efficiency. It is patently manifest that all firms producing at lower than average cost but receiving the same price as all others will realize a larger net share of the consumer's dollar than those having higher than average cost. A study we made of tomato packing cost in the Valley showed that cost diminished significantly with size of plant, length of season and quality of tomatoes handled. Certainly, the more efficient packers were in a position to do a better job for the producers.

But this competitive system, as we mentioned, is characterized by certain rules and requirements that must be met. Internally, producers compete among themselves for inputs necessary to grow a particular crop and also among producers of other crops requiring the same inputs. This tends to put upward pressure on prices of these inputs, land, water, labor, etc., and hence on costs of production. Externally, producers vie for opportunities to sell their produce, especially in long supply situations, which has a dampening effect on prices. Only the more efficient can endure this sandwiched-in level of returns, others must retire from the scene.

Those preferring not to go it alone must rely upon some form of group action. The cooperative idea was conceived in response to their need. Co-ops have provided producers the opportunity to bring into play a united though voluntary effort to relieve the vice-like pressure of the cost-price squeeze on producers incomes. They are named or classified according to the functions they perform in this capacity – the three major types being marketing, purchasing and service co-ops.

Co-ops have loomed large in the affairs of the fruit and vegetable industries for years. The Fruit Growers' Union and Cooperative Society of Hammonton, N. J., founded in 1867 was the first fruit marketing cooperative on record. (2) For over 70 years, Sunkist Growers, Inc.,

Los Angeles, Calif., has served citrus growers in California and Arizona. About 70 percent of all fresh citrus coming from this area is marketed by Sunkist. Two-thirds of all the orange and lemon products produced in the California-Arizona area are also processed and marketed by Sunkist. I have heard that Sunkist recently entered into an agreement to handle citrus sales for Blue Goose. It is said that this will up Sunkist's volume to around 80 percent of the oranges and 93 percent of the lemons from the area.

From 25 to 30 percent of all Florida fresh citrus sales are marketed under the Seald-Sweet trademark of the Florida Citrus Exchange, Tampa, a federated sales organization founded in 1909. More cooperatives market fruit independently in Florida than in California. But, the proportion of both fresh and processed citrus products marketed cooperatively is smaller in Florida than in California where virtually the entire crop is marketed by this method. (2) Three marketing associations handle citrus in Texas.

Services ranging from grove care to processing outlets are offered grower-members by many local cooperatives, as well as by federated or centralized associations. Procurement of spray materials, fertilizers, and other grove supplies are often included in these services. By owning their own fertilizer plant, members of a citrus cooperative claimed they cut their fertilizer cost a third. (3)

USDA's Farmer Cooperative Service placed the number of cooperatives in 1962 specialized in handling deciduous and other noncitrus fruits at 284. (2) The number of co-ops of all types marketing fruits and vegetables in 1962-63 totaled 640. (4)

It goes without saying that co-ops are intended to perform functions that would otherwise have to be carried out individually by competitive free enterprise producers. But through efficiencies derived from skill and centralized management, larger scale of operation, volume purchases, etc., they are able to buy inputs and production goods on more favorable terms. Moreover, cooperative ownership of packing, processing and marketing facilities extends producers control of their product considerably farther along in the channels of trade. This affords opportunities for lowering cost by reducing the number of ownership changes before products reach consumers. Also rewards from developing high quality uniform products belong to the grower rather than being retained by the marketing system. But co-ops offer much more than this. At a seminar on "What Cooperatives Contribute to the Consumer," Assistant Secretary of Agriculture George L. Mehren saw cooperatives making five main contributions: "Providing quality products, giving service to consumers, offering new products and processes, holding down production and marketing costs, and improving the general welfare." He further observed . . . "that cooperatives are certainly one of our brightest hopes to help farmers join together enough strength to compete under the new system and at the same time keep their age-old right to till their own soil." (3)

The economic debacle of the 1930's was responsible for legislation that made other types of valuable marketing tools available to farmers – marketing agreements and marketing orders. Briefly, the former are voluntarily entered into with the Secretary of Agriculture, the latter once issued are compulsory and apply to all producers and handlers of a product in an applicable production area. Federal orders apply to interstate commerce and foreign trade. Certain States have since endorsed the idea of marketing orders and have authorized intrastate regulation of fruit and vegetable marketing. Federal orders may provide for volume control, quality control, container regulations and regulations of unfair trade practices. State orders may not only provide for these regulations but may provide for advertising and promotion also. Last year, the Marketing Agreement Act of 1937 was amended by Congress to permit paid advertising for some 15 fruits and vegetables ranging from avocados to sweet corn.

Some 60-odd Federal fruit, vegetable, and potato marketing orders have been initiated since the mid-1930's. Considerably more than half are still in effect. In the neighborhood of a dozen States have some regulatory marketing programs.

Much has been said about marketing agreements with discussants usually adamantly lining up on the pro or con side asserting why orders will or will not work as the case demands. Seldom do we hear anyone begin with the proposition that an order conveys to producers, subject to the approval of the Secretary of Agriculture, the license or privilege to in some way change the economic environment. Accepting this, the relevant question becomes how and to what extent have growers utilized the extended privileges. Finally, it seems appropriate to judge success or failure in terms of how growers exercise these prerogatives in relation to effects both on the total industry and individual membership. This calls to mind something that has always been a matter of curiosity to me. Most discussions center on total industry effects, only lightly if ever on the impact an order will have on internal distribution of income among members of an industry. But though differently than in the competitive case, grade, size, and other regulations will affect differently the marketable supplies of crops of nonhomogenous quality. For better or worse, cost and price patterns will be altered and so will the relative net incomes among producers. I suspect that the uneasiness of coming out relatively worse off or better off is probably the dominant consideration concerning a producers attitude toward a marketing order rather than whether or not it will increase total industry returns.

Perhaps marketing orders are not a cure-all for marketing problems of all fruit and vegetable producing areas. However, they have withstood the tests of economics and time for some industry groups and have proven, particularly in conjunction with co-ops, to be powerful tools for protecting grower interests.

In passing, other possibilities could be mentioned. Growers might

avail themselves more of USDA market news reports now quoting grower prices for a number of fruits and vegetables. But even price reports that are f.o.b. only provide good bases for determining the tone of the market and for making meaningful estimates of grower prices.

Since grower-shipper contracts are the instruments stipulating terms of trade, producers might want to examine chances of including terms more favorable to themselves. The payoff from the adoption of uniform, standardized contracting procedures throughout the Valley may well be worth the effort. This is not to say that growers are without responsibility. They should energetically examine possibilities of encouraging volumes large enough for efficient handling and of reducing fragmentations of sales for several reasons. Large volumes usually carry more thrust in the market, and chances are improved for furnishing large-scale buyers and others uniformly high quality products in the quantities needed. Cost reductions and efficiencies so generated can be in harmony with the interests of producers, handlers, buyers, and consumers.

Growers should inventory all tools, market reports, possibilities for improving personal efficiency and potential advantages of co-ops and Federal and State orders, to be sure they are making maximum utilization of opportunities available to them. Then and only then will they realize their full potential in the market place.

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Present Status of Mechanical Harvesting of Fruit and Vegetable Crops[1]

JORDAN H. LEVIN[2]

Harvesting has become a major problem in all fruit and vegetable production areas. Harvesting fruit and vegetables is hard, back breaking, often dirty, disagreeable work. Most people will not do this type of work unless they are hungry. Under the economy which we are enjoying not many people are hungry. The only logical answer to this serious problem is mechanization.

Agricultural Engineering Research Division (AERD), ARS, USDA, is conducting research on harvesting citrus, deciduous fruit and potatoes in cooperation with several of the land grant colleges. Agricultural schools as well as private industry are also attempting to develop equipment for harvesting fruits and vegetables. In the last few years much progress has been made. Much more needs to be made. The following is a brief summary of some of the harvesting research on crops which are grown in the Rio Grande Valley.

Citrus

Considerable work is underway. At Lake Alfred, Florida prototype tree shaking and collecting equipment has been developed for harvesting fruit which will be processed.

This equipment can result in a saving of 10c a bushel on grapefruit and 2c or 3c a bushel on oranges. We are hoping that this equipment will be tested under commercial conditions during the next year.

The use of pulsating air is being investigated. With pulsating air over 95% of the grapefruit can be removed and over 90% of the oranges. However, leaf damage results. Much more research needs to be done to determine if this method is feasible.

Many other detachment methods and devices are under study. These consist of spindles, vacuum twisting devices, rollers, combs, etc. All are in the experimental stage and must be incorporated into a complete machine.

Chemicals and dc electricity are being investigated to determine whether their use can cause abscision. Both methods look promising.

[1] Presented at the Twentieth Annual Horticultural Institute, Rio Grande Valley Horticultural Society, Weslaco, Texas, January 25.
[2] Leader, F & VHI, AE, ARS, USDA, East Lansing, Michigan.

There is much research underway in developing aids for the human picker. Aids are platforms and man positioners. A platform is a unit in which a worker has freedom to move about just as if he were on the ground. In my files, I have records of over 50 grower-made platforms. Some of these are simple platforms which are fixed at one height. Others are quite elaborate and have cylinders which will raise and lower them and also have catwalks which will move in and out. A man positioner is a device having a cage or basket. A worker in the cage or basket can move it to any position in the tree by operating controls with his feet or hands. There are over 25 different types on the market and growers have made units of their own. Some of these are quite ingenious. However, most of them cost from $2500 to $8000 and are too high priced if they are going to be depreciated just for harvesting. The USDA, in cooperation with the University of California at Riverside, have been developing a low cost positioner called the Power Ladder. It is hoped that this unit will sell for about $1500. A 36% increase in picking efficiency was obtained during a 3 month test where the machine was used daily.

Cherries

Although other tree fruits are not grown extensively in the Valley, you might be interested that the harvesting of tart cherries has been mechanized. This year the equipment will replace 7000 workers and actually save growers about 1 million dollars.

Prunes and Dates

Prunes and dates have been also mechanized with a corresponding labor saving.

Blackberries

Blackberries are grown in Texas. You might be interested that there have been several machines developed for berry crops. In fact, approximately ⅓ of the bush berries in Oregon is harvested mechanically. A blackberry harvester was tried in Texas last year and shows real promise. It was developed at the University of Oklahoma and is being made in Michigan.

Strawberries

Up to now very little has been done. Experimental units at the University of Illinois and Iowa State show that strawberries can be raked off. However, new varieties will be needed which would have high yields per acre with uniform ripening and which could be harvested at one time.

Tomatoes

Mechanical harvesting of tomatoes is a reality in California. Last year approximately 270 machines harvested over 15% of the crop. These machines averaged 100-105 acres each, harvested 10 tons per hour, and each recovered 20-25 tons per acre. The reason that harvesting of tomatoes mechanically in California has been so successful is the variety (VF 145) which ripens at one time and has high yields. Five or six different make machines are in use. The Blackwelder Company has the most units in use. The machines all operate on the same principle. They either cut off or dig up the vines and get them up on the machine. Tomatoes are shaken off and the vines put back on the field. Sorters throw out green tomatoes.

Cabbage

Several experimental units for harvesting cabbage for processing outlets are being tested. New York, North Carolina and Michigan have experimental units as well as FMC and one or two growers. The units seem to work satisfactorily for processing but not for fresh market. They work better when the cabbage is seeded than when transplanted and work better with some varieties than others. More work is needed before many growers will use them.

Lettuce

Lettuce is a crop which is being mechanized in California. Two machines have been developed; one at the University of California and the other at the University of Arizona. Prototype machines have been made by commercial companies and tested this past year. Lettuce in California will be harvested mechanically this year and there will be a number of machines used. Major problems are still cultural in that lettuce must be in straight lines, in the center of the hill, and spaced properly.

Melons

Research on development of a harvester for melons is underway at the University of California. The problems are cultural in that a variety must be found that can be harvested in two or three harvests instead of six or seven and still have high yields.

Cucumbers

Two different principles are being tried for harvesting cucumbers. Commercial machines using each principle are now available. Chisolm Ryder has a multi-harvester unit. FMC has a once over harvester. Again, cultural problems are present. However, there will be 50-100 units in use this next year and much will be learned. These units are for harvesting cucumbers which will be processed.

Other Crops

There are experimental machines for asparagus, celery, and sweet

corn. Commercial machines are already being used for snap beans, spinach, radishes and some other crops.

As you can see there is much being done. However, you must realize that it takes time to develop a machine and modifications are needed for each area. Most of the many machines now being developed are for processing outlets but with additional research these machines could be used to harvest fresh fruits and vegetables. Growers should not expect miracles but if they cooperate in all of the developments, equipment and methods will be found to harvest most of our crops.

A Typical Diurnal Temperature Pattern During a Frost and Light Freeze

Donald J. Haddock[1]

ABSTRACT

A typical wintertime diurnal temperature pattern during a frost and light freeze is discussed and illustrated. The decrease in temperature between the "high" during mid-afternoon and "low" around sunrise is at the half-way point at approximately 8:30 p.m. (2¼ hours after sunset). The accompanying graph is useful in projecting the current nighttime temperature curve so that the "low" and time and duration of any critical values can be estimated.

Being familiar with the daily, especially nighttime, temperature pattern during the cold months is important to growers operating cold protection equipment on critical nights. The rapid decrease of temperature during the late afternoon and early evening may cause unwarranted anxiety if this same rate is used in projecting the temperature curve for the remainder of the night. One-half of the temperature fall between the mid-afternoon "high" and early morning "low" has usually taken place by 8:30 p.m. when clear, cool, dry and calm (or light wind) conditions exist.

A typical diurnal temperature pattern during a frost and light freeze is shown in the accompanying graph. The curve was prepared by using hourly temperature values from an aspirated thermometer at the McAllen FFA weather station between noon of January 29 and noon of January 30, 1966. At that time a high pressure ridge and associated cold dry air mass were over the local area in the aftermath of a cold frontal passage just before midnight on January 28.

During the 24-hour period of basic data, the hourly temperatures ranged from 53.0°F at 4:00 p.m. to 28.8°F at 7:00 a.m.; the sky was clear, the dew point averaged 28.3°F, a light to gentle northerly breeze prevailed, sea level pressure averaged 30.36 inches (1028 millibars) of mercury, sunset was 6:14 p.m. and sunrise was 7:18 a.m.

The characteristic daily temperature pattern shows the "high" about mid-afternoon and the "low" around sunrise. The temperature decreases rapidly during the late afternoon and early evening, but the rate becomes progressively slower during the night and finally terminates with the occurrence of the "low" around sunrise. Temperatures begin to rise rapidly about one-half hour after sunrise. The rate of increase gradually tapers off a little past noon.

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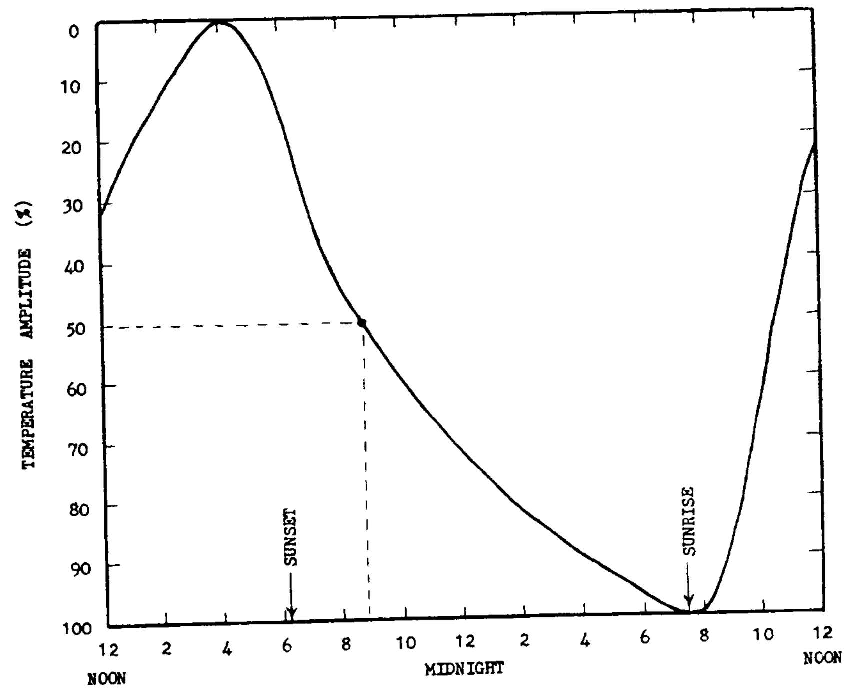

Figure 1. A typical diurnal temperature pattern during a frost and light freeze. Fifty percent of temperature decrease between the mid-afternoon "high" and early morning "low" has taken place by 8:30 p.m. McAllen, Texas, January 29-30, 1966.

The amplitude scale of the temperature graph has been adapted to percentage values. Zero % corresponds to the highest and 100% to the lowest hourly temperature during the noon-to-noon period. Thus, the amplitude values represent the percent of the diurnal temperature fall at any time between mid-afternoon and sunrise. For example, 25% of the temperature falls has taken place by 6:30 p.m., 50% by 8:30 p.m., and 75% by 12:30 a.m. To approximate the total fall, multiply the temperature decrease between 4:00 p.m. and 6:30 p.m. by four; between 4:00 p.m. and 8:30 p.m. by two; and between 4:00 p.m. and 12:30 a.m. by 1.3.

To estimate the low temperature, subtract the approximate total fall from the mid-afternoon or 4:00 p.m. "high." By using the estimated "low" and accompanying graph as a guide, the current nighttime temperature curve can be projected to indicate time and duration of any critically cold values.

Estimating Citrus Tree Temperature on Cold Nights Before and During Heating[1]

R. F. Leyden, R. A. Hensz, and J. E. Fucik[2]

ABSTRACT

Temperatures registered at the 5 ft. level in the center of the tree and at an "inverted L" thermometer stand outside of the foliage of the tree were investigated under heated and non-heated conditions. The temperature registered in the thermometer stand was a practical guide to tree temperature. Temperature differences between thermometer stand and center of the tree are given for non-heated conditions, and when fuel blocks are burned under the tree or between the trees.

INTRODUCTION

The citrus grower interested in cold protection must be able to make a quick meaningful estimate of the temperature in his orchard whenever freeze conditions are likely. He must also be able to evaluate the effectiveness of any heating that may be undertaken.

An accurate glass thermometer is an excellent device for estimating temperature. In the orchard the thermometer must be exposed in such a manner that the temperature observed will have some known relationship to the temperature of the tree.

The standard shelter used by the Weather Bureau is designed to provide uniform exposure of thermometers so that temperatures observed in different locations can be compared. Shelters of this type are rather costly for widespread use in the orchard. Haddock (1964) compared minimum temperatures registered in several types of simpler thermometer shalters with minimum registered in a cotton region shelter, the Weather Bureau standard for this area. One of these, a newly designed shelter, was found to agree with the cotton region shelter within 0.3 F.

In California glass thermometers in simple "inverted L" thermometer stands have been used for many years as a guide to orchard temperature (Young and Harmon 1948). This technique has been in use at the Citrus Center since 1955. Cold protection experiments during the winter 1965-66 provided data to investigate statistically the relationship between the temperature registered at thermometer stands and the tree temperature.

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MATERIALS AND METHODS

The thermometer stands were of extremely simple wood construction as shown in Figs. 1 and 2. Materials included a 2 x 2 in x 7 ft. post, 2 pieces each 1 x 4 x 18 in, wood screws, and nails. The stands were installed so that thermometers were uniformly 5 ft. above ground.

Test areas were instrumented for temperature measurements in the manner previously described (Leyden, et al., 1965). At each location 20 trees in the heated area and 20 trees in the surrounding non-heated area had thermocouples in the center of the tree at a point 5 ft. above ground. At each tree a thermometer stand was located 1 to 2 ft. outside of the foliage on the east side of the tree. A thermocouple was secured to the stand in the same position as the sensing element of a glass thermometer. By using the potentiometer-thermocouple set up tree temperature and corresponding thermometer stand temperature could be read within a few seconds. On test nights readings were made hourly. Heating was by means of petroleum coke fuel blocks placed under or between the trees.

Temperatures during the tests were above freezing. Winds were

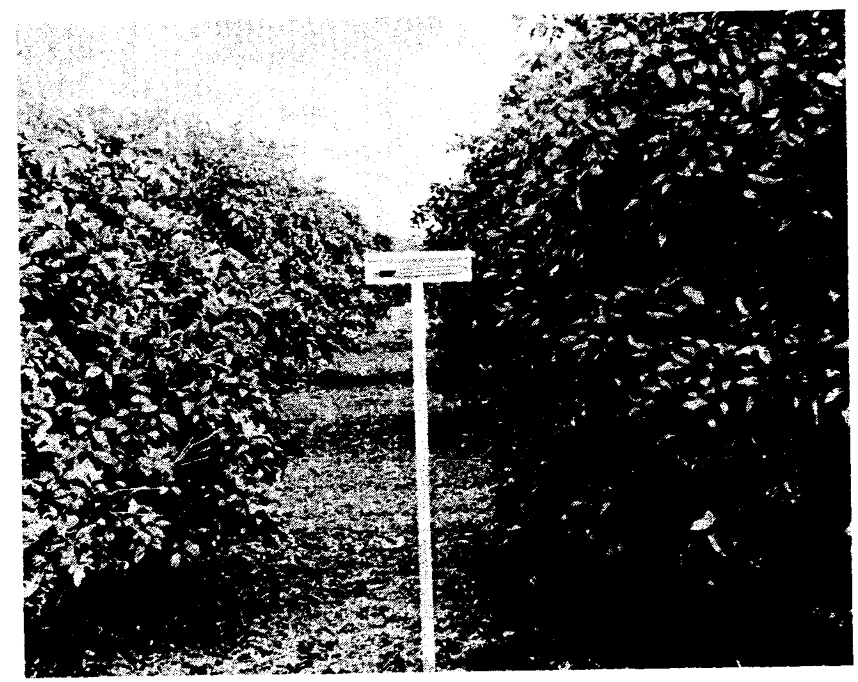

Figure 1. "Inverted L" thermometer stand located 1 to 2 ft. outside the foliage of a tree.

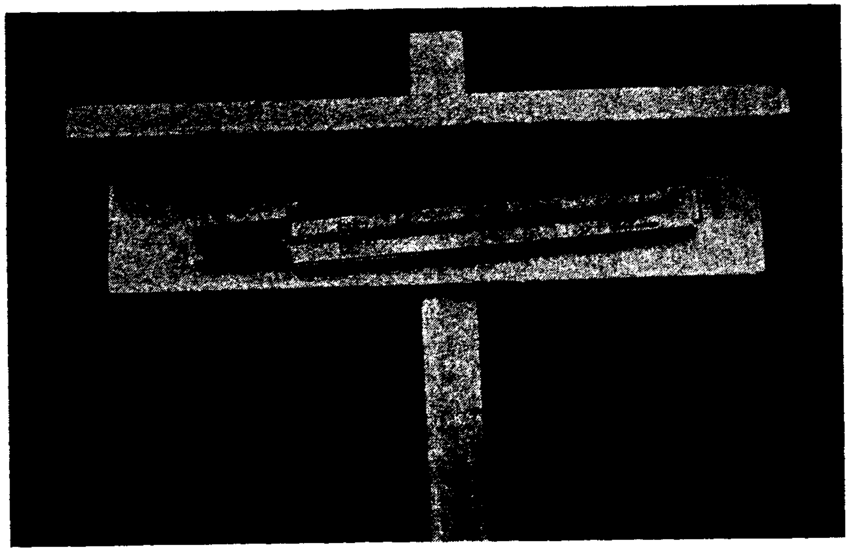

Figure 2. **Minimum registering orchard thermometer installed in an "inverted L" thermometer stand.**

from 0 to 2 mph. Weather data and details of amount and placement of fuel blocks are given in another paper in this journal (Leyden, et al., 1966).

RESULTS AND DISCUSSION

In Table 1 temperature data for a typical under the tree heating test are presented. Each value is the average of 20 trees. In the third column the temperature difference between the center of the tree and the thermometer stand is listed. The average difference for the night was about 1 F in the non-heated area and about 3 F in the heated area; the higher temperature being in the center of the tree in each case.

Each test night provided at least 100 paired observations in heated and non-heated areas. The temperature differences, calculated as center of the tree minus thermometer stand, were subjected to statistical techniques designed for analyzing differences between paired observations (Snedecor, 1956). Such analysis can provide a confidence interval, or range, between which differences will probably fall in 95% of the cases. Table 2 lists the confidence interval for each test night under heated and non-heated conditions.

Considering first non-heated conditions, while there are differences between nights, a useful relationship does exist. The thermometer stand will be colder than the tree. The difference may be as little as ¼ degree or as much as 1¾ degrees.

With under the tree heaters burning, 2 or 3 units to a tree, the temperature at the 5 ft. level in the center of the tree can be expected to be from 1 to 4½ degrees warmer than that observed at the thermometer stand.

With small heat sources burning in the open between the trees the center of the tree will be less than 1 degree warmer than the thermometer stand.

In each instance, whether heated or non-heated, the thermometer stand registers a temperature lower than that at the center of the tree. Keeping the confidence interval in mind, an "inverted L" thermometer stand can be a practical guide to tree temperature.

In the orchard, thermometer stands should be set out with the thermometer facing north so that it is not exposed to the direct rays of the sun. Minimum registering thermometers of the type illustrated in Fig. 2 are recommended. These are available locally, are reasonably priced, have an accuracy of ±0.5F, and are easily read. The latter is a definite asset considering that the important readings will be made at night with the aid of a flashlight.

The number of thermometers and their exact location will vary with the individual orchard. Past history can provide some knowledge of the

Table 1. Temperature 5 ft. above ground at the center of the tree and at a thermometer stand outside of the skirt of the tree during an under-the-tree heating test, 3 February 1966.

Time	Temperature F: Center of tree	Temperature F: Thermometer stand	Difference
(hours)	(average of 20 tree)		(tree - stand)
	Non-heated area		
0*	40.9	39.3	1.6
1	38.4	37.4	1.0
2	37.5	36.4	1.1
3	37.0	36.1	0.9
4	36.6	35.5	1.1
5	35.0	34.2	0.8
6	34.1	33.2	0.9
	Heated area		
0	40.1	38.3	1.8
1	42.2	39.1	2.1
2	42.2	40.0	2.2
3	43.1	39.2	3.9
4	41.9	37.3	4.6
5	39.7	36.1	3.6
6	37.5	34.6	2.9

* 0 = time fuel was ignited

Table 2. Confidence interval for temperature difference (center of tree minus thermometer stand) in non-heated and heated areas during heating tests.

		Confidence interval (degrees F)	
		Non-heated	Heated
Location 1.	20 December 1965	0.60 to 0.72	1.53 to 2.63
	5 January 1966	0.27 to 1.31	2.77 to 4.60
	15 January 1966	0.48 to 0.93	2.55 to 3.53
	3 February 1966	0.97 to 1.49	2.90 to 3.70
Location 2.	15 January 1966	0.86 to 1.54	1.22 to 2.42
	* 3 February 1966	1.27 to 1.75	0.38 to 0.88

* Fuel blocks burning in the open between the trees, 3 February at location 2. In all other tests fuel burned under the tree.

colder locations where thermometers should first be installed. When no knowledge of temperature differences exists a number of stands should be set out. A minimum of 4 on a 10 acre block is suggested. On all clear, still, cold nights thermometers should be read to get information as to natural temperature differences that may exist.

Growers using glass thermometers should avail themselves of the testing service offered by the Weather Bureau Agricultural Service Office in Weslaco. Thermometers are checked for accuracy and tagged with a correction factor if necessary. The service is well publicized before the onset of the cold season each year.

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Thermal Patterns of Solid Fuel Block-Heated Citrus Trees[1]

Craig Wiegand, Victor Myers, and Norman Maxwell[2]

ABSTRACT

An infrared camera and a radiation thermometer were used to study the thermal pattern of citrus foliage associated with the use of solid fuel blocks under one moderately windy and one calm condition. Single fuel blocks on the W and NE sides of the tree were insufficient to warm the S side of the tree when the wind was 6-10 mph from the NE. Under conditions of slight drift of wind from the NW, overcast sky, and 4 fuel blocks under a large tree with full skirt, air temperatures at the 5-foot height, 3 and 6 feet from the center of the tree were 8 to 14 F above outside air temperature on the downwind side whereas external foliage temperatures were within 2 F of air temperature. Under clear sky conditions external foliage was as much as 5 F colder than the air.

The results demonstrate the usefulness of the noncontact infrared techniques for measuring the complex foliage thermal patterns which result when under-the-tree solid block energy sources are used. The instruments may be particularly suited to studies under windy conditions.

Tests with under-the-tree heaters have been reported by several workers (Young et al, 1964; Leyden, Hensz, and Fucik, 1965; Maxwell and Bailey, 1965; Bailey and Maxwell, 1965). In all these studies thermometers or thermocouples were used to sense air, leaf, fruit, and bark temperatures.

Infrared thermometry (Smith, Jones, and Chasmar, 1960) has made available additional tools for the study of thermal phenomena. This paper presents data obtained with an infrared camera (Barnes, 1963) and a radiation thermometer (Wormser, 1964) of temperature patterns associated with the use of solid block under-the-tree heaters.

METHODS AND MATERIALS

Two experiments were conducted. The first was conducted the afternoon and evening of January 22, 1966, using the two trees shown in Figure 1 as the target. Single solid fuel blocks had been placed about

[1] Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, and the Texas Agricultural Experiment Station, Texas A&M University.

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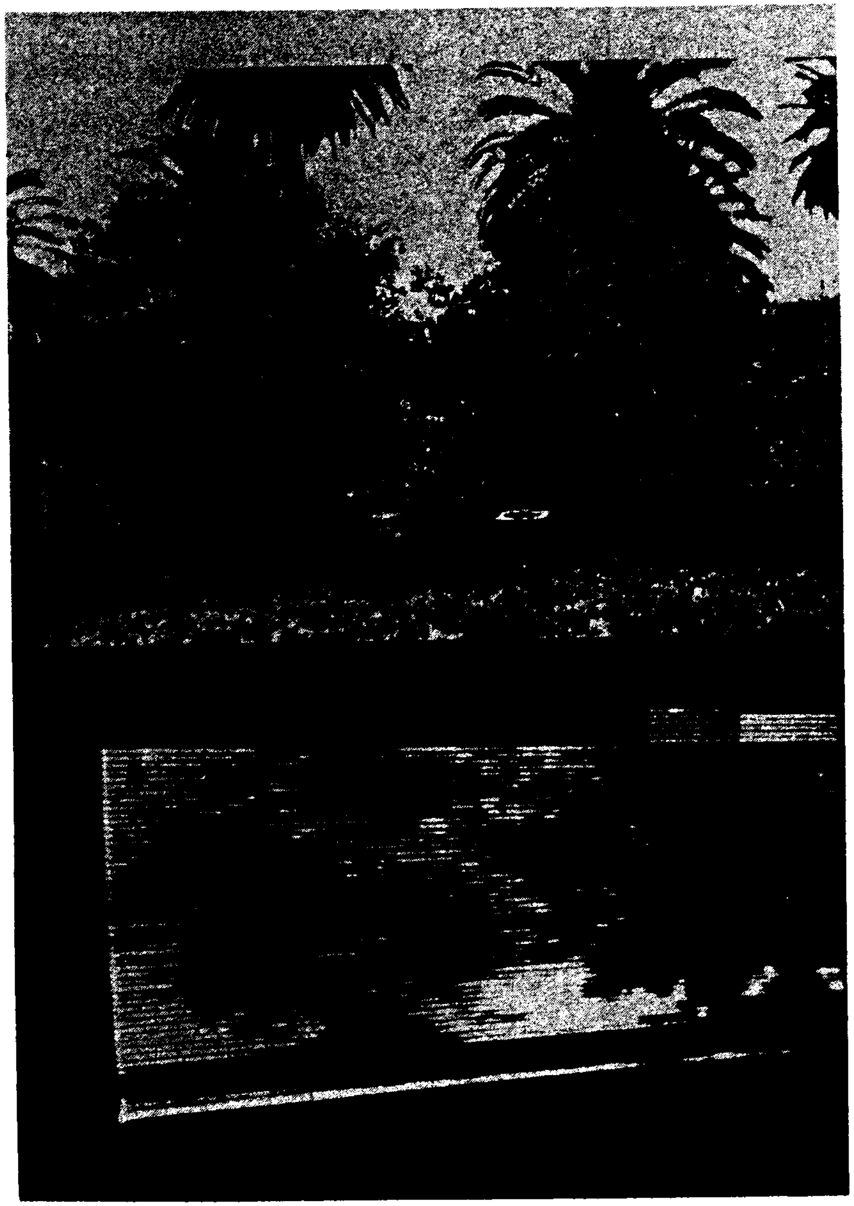

Figure 1. **Panchromatic photograph and thermogram of target trees of Experiment 1.** (In the thermogram the lighter in tone an area is, the colder it is.)

3 feet from the trunk on the NE and W sides of each tree. Air temperature dropped from the high 50's in the afternoon to 34 F at midnight. The fuel blocks were ignited at 11:15 p.m. Windspeed was 6-10 mph from the NE and the sky was clear.

The second experiment was conducted between 6:00 and 7:00 a.m. on February 25, 1966. Thermal phenomena of a single large grapefruit tree (Figure 3) on the N side of a grove in which heaters had been lit over a 1½-acre area during the night was studied. This tree, which was about 16 feet in diameter and 15 feet tall, had a full, low skirt. In the 1½-acre heated area one heater was placed 3 feet from the trunk on the N, E, S, and W sides of each tree. Thermometers accurate to ±0.5 F were hung in the test tree at the 5-foot height on the N, E, S, and W sides at 3 and 6 feet from the trunk. Air temperature was 49 F, the air was calm, and the sky was heavily overcast.

The infrared camera used was the Barnes Model T-5[3] [4]. This camera functions by focusing radiation from the target upon a thermistor. The electrical output from the thermistor modulates the intensity of a glow tube. The fluctuating light from the glow tube exposes POLAROID[5] film. Thus a photographic image of the thermal pattern, a thermogram, is produced. The instantaneous field of view is 3 milliradians (0.2 degree) but by scanning one line per second in raster fashion a thermogram with a 10 by 20 degree field of view is produced in 1 minute. The instrument automatically prints an eight-step gray scale as the last several scan lines of the thermogram. Thermogram interpretation is made by comparing a point or spot on the target with the tone on the gray scale. From the electronic settings at which the thermogram was taken a radiance is calculated which is then convertible to an equivalent blackbody temperature. The temperature range encompassed by the gray scale can be varied to include the temperature range in the target. Targets either warmer (positive target setting) than or colder (negative target settings) than the reference body temperature may be photographed by proper adjustment of the settings.

The infrared thermometer used was the Barnes[4] Model PRT-4. This instrument has a spectral bandpass of 8 to 14 microns. This is an excellent bandpass interval for detection of thermal radiation emitted by objects in the 20 to 60 F temperature range since peak intensity of emission occurs near 10 microns. The field of view for this instrument is 3 degrees. Incident thermal radiation from the target is continuously compared with the thermal radiation of a built-in 131 F reference temperature body. In use the instrument sensing head is simply aimed at the target of interest and the indicated target temperature is read off a meter.

[3] Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product by the U. S. Department of Agriculture or the Texas Agricultural Experiment Station.
[4] Barnes Engineering Company, Stamford, Connecticut.
[5] The Polaroid Corporation, Dallas, Texas.

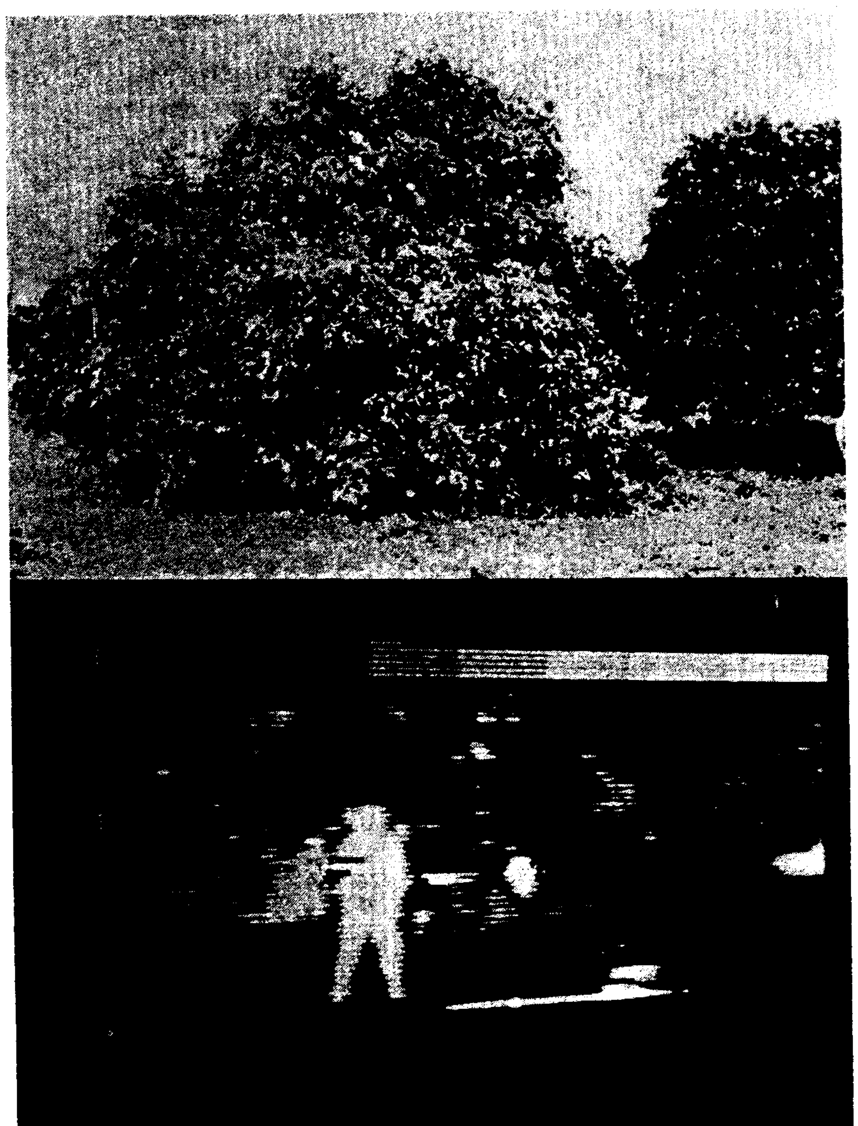

Figure 3. Panchromatic photograph and thermogram of single grapefruit tree of Experiment 2. (Person in thermogram is Wayne Swanson.)

In Experiment 1, the tree rows were oriented E-W and all pictures and thermograms were taken from the S side of the trees. In Experiment 2, the tree rows were oriented N-S and all pictures and thermograms were taken from a slightly northwesterly orientation with respect to the tree rows.

RESULTS

EXPERIMENT 1

A panchromatic photograph of the trees studied and a thermogram of the trees taken at 5:05 p.m. January 22 are presented in the upper and lower portions, respectively, of Figure 1. Three of the heaters used are visible in the panchromatic photograph. The thermogram in the lower part of Figure 1 was taken with a negative target setting because the air temperature was 37 F but the camera was still warm (51 F) from recent transport from the laboratory. The temperature difference from thermogram gray scale step 1 (warm) to gray scale step 8 (cold) is 3.5 F. The thermogram shows that the ground under the trees is warmer than the sod beyond the trees and that branches (left tree) and some of the foliage overhung by other leaves is warmer (both trees) than fully exposed foliage.

Figure 2 is a composite of two thermograms taken during the evening. The upper thermogram was taken at 11:10 p.m. just before lighting the fuel blocks and the lower one at 11:35 p.m., 20 minutes after the fuel blocks were lighted. In both thermograms the lighter in tone an area is the warmer it is since a positive target setting was used.

The calculated temperature range in the upper thermogram corresponding to gray scale steps 1 and 8 is 3.6 F. The lower thermogram has a calculated temperature difference between steps 1 and 8 of 7 F. However, much of the area in the thermogram is whiter than step 8 on the gray scale so that the full temperature range is not defined. A thermogram obtained at midnight with a wider temperature range in the gray scale indicated temperature differences of 18 F among locations on the trees. In the lower thermogram of Figure 2 the upper foliage of both trees has been warmed. The south side of both trees is, for the most part, unheated. The roughly triangular dark area at the center of the right tree is unheated. The pattern for the left tree is more complicated than that of the right tree. The two dark patches located at the lower left and right center of this tree correspond to foliage which portrudes outward (S) and the narrow dark line separating the dark patches is a limb (see panchromatic photograph of Figure 1).

The exterior foliage temperatures presented in Table 1 obtained with the radiation thermometer before and after lighting the fuel blocks agree with the thermograms. The W and N sides of the left tree were warmer than the S and E sides. The E and W sides of the right tree were warmer at the 5- and 7-foot levels than the N and S sides. The 3- and 5-foot heights were warmed on the N side but the 7-foot height was not. Considering that the fuel blocks were placed on the NE and W

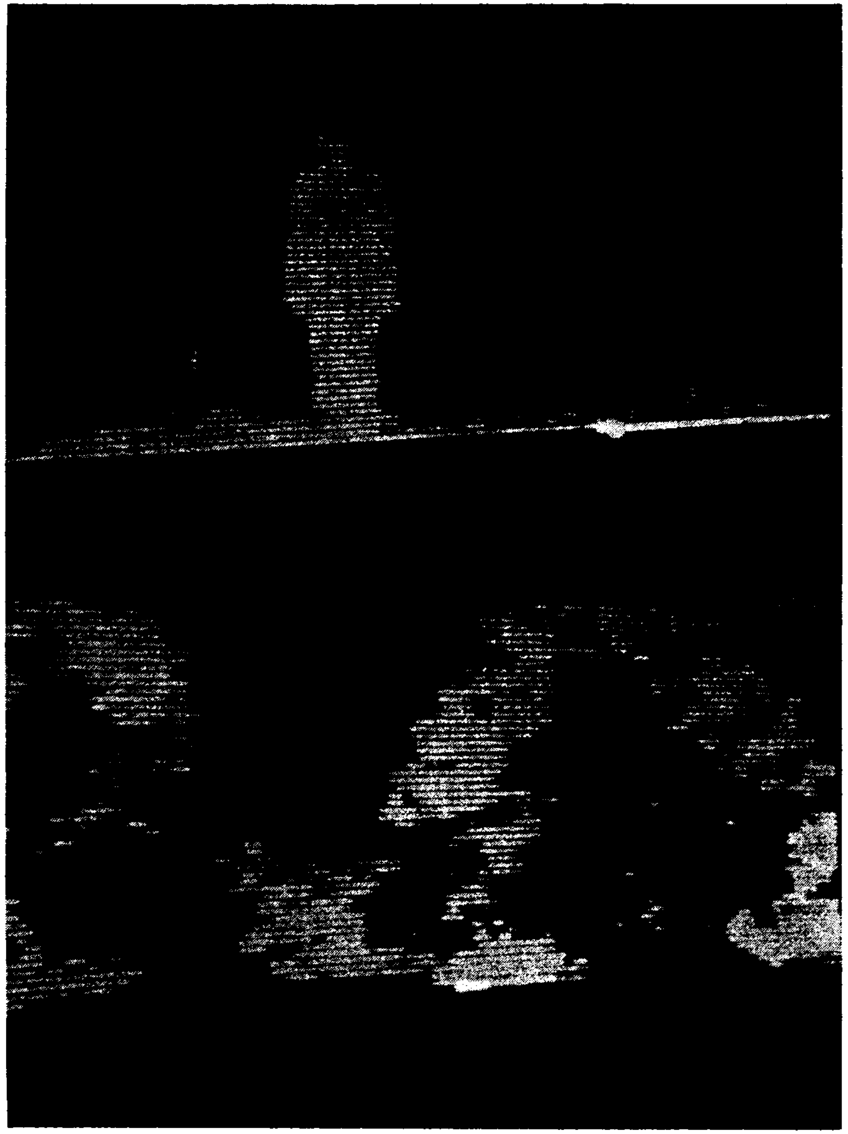

Figure 2. Thermograms of the trees of Figure 1 taken before (top) and after (bottom) lighting the fuel blocks. (In these thermograms as in those of Figures 3 and 4 the lighter in tone an area is the warmer it is. Person in upper thermogram is Charlie Rankin.)

Table 1. Temperatures of line-of-sight foliage at 3, 5, and 7 feet on south, west, north, and east sides of trees in Experiment 1 before (10:30 p.m.) and after (11:45 p.m.) lighting fuel blocks January 22, 1966.

Tree in Fig. 1	Hr.	Height Ft.	Foliage temperature by quadrants: South °F	West °F	North °F	East °F	Air Temp. °F
Left	10:30	3	31	35	36	36	35
		5	31	35	36	35	
		7	33	34	35	33	
Right		3	35	35	34	35	
		5	32	34	34	32	
		7	31	34	34	34	
Left	11:45	3	31	38	55	34	34
		5	33	45	39	38	
		7	34	42	29	30	
Right		3	36	43	53	41	
		5	32	51	35	47	
		7	37	48	29	55	

sides of the trunk and that the wind was blowing 6-10 mph from the NE, these thermal patterns are reasonable.

The low leaf temperatures of Table 1 relative to air temperature are in agreement with the finding of Curtis (1936) that citrus leaves exposed to a clear sky could be as much as 4 F below those shielded from the sky. The number of foliage temperatures below air temperature on the protected S side of the tree in Table 1 indicates that unheated leaves on this side of the tree were radiating to space.

EXPERIMENT 2[6]

The tree of this study and a thermogram of the thermal pattern resulting from burning 4 fuel blocks are depicted in the upper and lower portions, respectively, of Figure 3. A study of the thermogram reveals that the bright white spots at the waist high level of the person in the thermogram are the heaters themselves and that the gray tones generally correspond to holes in the foliage canopy or areas that have other foliage hanging out over them. There are more gray areas on the right (S) side of the tree than on the left (N) side. The temperature range of the gray scale is 6 F. Exterior foliage such as that just above the head of the person in the thermogram is of uniform temperature but outside (cooler) the thermal range of the gray scale.

[6] The fuel blocks of this experiment were developmental models. They burned rather unevenly and with a lower BTU output than the optimal 15,000 to 20,000 BTU per hour.

Exterior foliage temperatures measured with the radiation thermometer and air temperatures measured by thermometers in the canopy of the tree shown in Figure 3 are presented in Table 2. The radiation thermometer data show that the exterior foliage temperatures varied about 3 F from N to S side of the tree. The thermometer data taken at the 5-foot height, 3 and 6 feet from the center of the tree show that the air temperature inside the tree canopy was essentially the same as outside air and foliage temperatures at the N and W quadrants but as much as 8 to 14 F warmer than exterior air on the S and E sides. The temperatures 6 feet from the trunk in the S and E directions were 3 to 4 F warmer than at 3 feet from the trunk.

The evident easterly drift of the wind suggested by the data of Table 2 is apparent in the thermogram of Figure 4. This row of trees was 1 row W of the single tree but well within the 1½-acre heated area. The thermal patterns visible in the thermogram correspond to heaters under tree numbers 2 to 7 in the N-S row.

DISCUSSION

Under-the-tree heaters are used to place the heat where it is needed to save the trunk and large limbs. The tree canopy helps trap the heat. The general consensus is that 3 or 4 fuel blocks, each of 15,000 to 20,000 BTU per hour heat output, per tree placed 3 to 4 feet from the trunk in each quadrant can protect the framework wood of large trees under rather severe conditions. Even though the experiments reported herein were not conducted under disastrouslv cold conditions they are in general agreement with the recommendations. For example, two solid fuel blocks, one on the W and one on the NE of the trees of Experiment 1, were insufficient to warm the S side of the trees. The fact that the exterior foliage was near air temperature in Experiment 2 whereas interior tree temperatures were 8 to 14 F above air temperatures on the

Table 2. Temperatures at the 5-foot height of exterior foliage and of air inside a single tree canopy at 6:40 a.m. on February 25, 1966.

	Exterior foliage °F	Interior air: 3 ft. from center °F	Interior air: 6 ft. from center °F
North	48	49	49
Northwest	49	----	----
West	49	48	49
Southwest	50	----	----
South	51	57	60
East	----	59	63
Inside canopy, east side	57		
Trunk	60		
Ground outside tree	51		

Figure 4. Panchromatic photograph and thermogram of row of grapefruit trees of Experiment 2.

S and E sides is evidence that the tree canopy is very effective in trapping heat. In this regard, a full low tree skirt would favorably reduce windspeeds and, consequently, energy advection. A comparison of thermograms under the windy (Experiment 1) versus calm (Experiment 2) conditions suggests that some leakage of heat to the exterior leaves under conditions of strong radiational cooling is desirable.

The infrared camera and radiation thermometer make exterior foliage temperatures and the details of complex thermal patterns readily accessible to study. Thus these instruments may be of particular interest in studying heater performance under windy conditions.

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Performance of Petroleum Wax Under-the-Tree Heaters on Citrus During a Freeze in the Winter Garden of Texas

Norman P. Maxwell and John Carpenter

Research work with petroleum wax under-the-tree heaters done in 1964 (Young et al. 1964) and 1965 (Maxwell and Bailey) (Bailey and Maxwell) in citrus groves in the Lower Rio Grande Valley of Texas indicated that temperatures could be raised enough to protect the major framework limbs and trunks of citrus trees from freeze damage. Most of this work was done under non-freeze conditions. A paper by Don Haddock in 1965 showed that by using a Carrier Corporation psychrometric chart it essentially requires the same amount of heat to raise the temperature 10°F at 40°F or at 20°F. This test was conducted to determine the effectiveness of a new experimental under-the-tree petroleum wax heater designed by Sinclair Refining Company and to determine the performance of under-the-tree heaters under actual freezing conditions.

MATERIALS AND METHODS

The solid fuel blocks used in the test were an experimental model developed by Sinclair Refining Company. The blocks were composed of a container made from concrete and a light weight aggregate that held 10 pounds of petroleum wax. The size of the container was 7¾ inches high and 9¼ inches square with a loose asbestos partial cover on top so that the wax would burn at the rate of 20,000 B.T.U.'s per hour for a 10 hour period.

This heater differed from other petroleum wax heaters tested in that it did not use any wick. The wicking action was provided by the absorption of wax in the side of the concrete container. A paper cross was inserted into the block at the time of pouring the wax to aid in the initial ignition of the heater. A plastic material was used to coat the outside of the containers so that the melted wax could not penetrate the wall and run out on the ground.

Metal backed thermometers calibrated in 1°F increments with an accuracy of ±0.5° were used to record the temperatures. Five thermometers were placed in an unheated tree at the 5-foot level in the center of the tree and 3 to 6 feet north and south of the center. In the heated area, 3 trees had thermometers placed at the 5-foot level in the center of the tree and in all 4 quadrants 3 and 6 feet from the center.

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The heating test was conducted on an acre of mature citrus trees about 12 feet in diameter and 12-15 feet tall. The canopies of the trees were tight and close to the ground, thus helping hold heat within the tree.

The night the test was run, January 29, 1966, was cold and clear with a wind of about 5-15 miles per hour from east and southeast. The wind velocity was 5-7 miles per hour when the test was started but gradually increased to 10-15 miles per hour with possibly gusts even higher before the test was completed.

Three heaters were used per tree. These were placed 3 feet from the trunk on the north, east and west sides of the tree. The lighting sequence was the north side, then the east side and the west side last. This sequence was used because the direction of the wind was from the east and southeast. A standard grove torch using a mixture of half gasoline and half diesel fuel was used to ignite the blocks.

The test was started after the ambient temperature had reached 30°F. The heaters on the north side of the trees were lit first then allowed to burn 30 minutes so that they would reach their output of 20,000 B.T.U.'s per hour. A reading of the temperatures in the unheated and heated area was taken at the end of the 30 minute period, then another reading was taken 15 minutes later. After the second reading another heater was lit and the same time sequence was followed for burning and reading temperatures as was done with the first heater. This timing was repeated for the third heater on the west side of the tree.

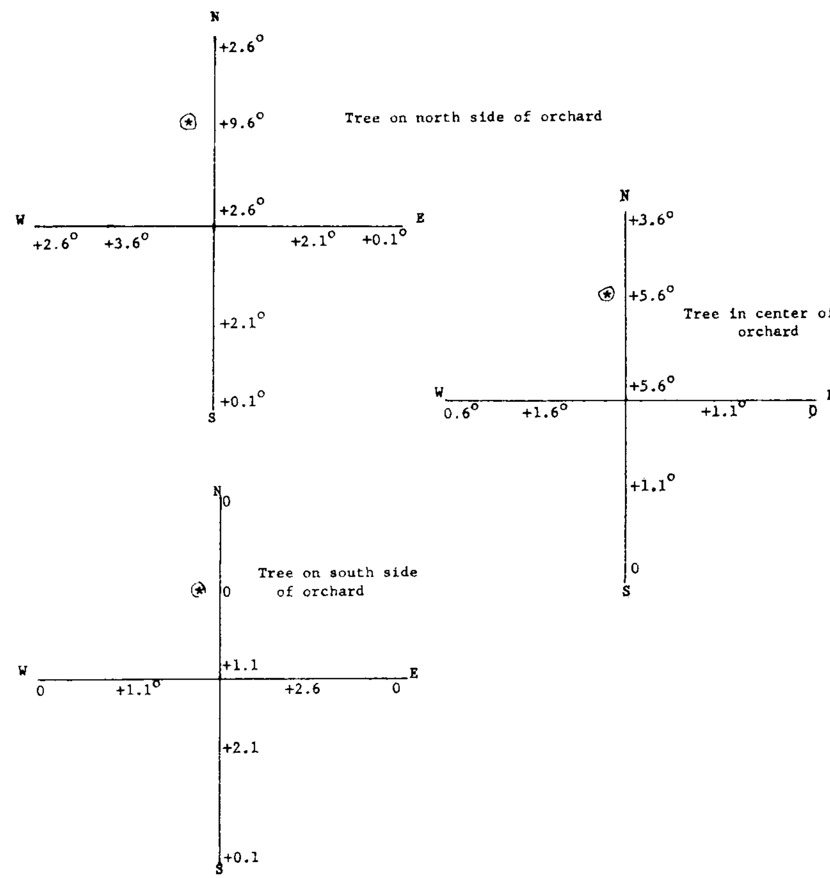
RESULTS AND DISCUSSION

Tables 1, 2 and 3 give the results obtained in individual test trees on the north, center and south sides of the heated area. These tables also show heat dispersion patterns with 1, 2 and 3 heaters burning.

When only one heater was lit the area of effective heat was rather limited and the results obtained in the heat pattern was a chimney effect. With two heaters burning, the heat columns apparently converged and gave a much better dispersed heat pattern through the center of the trees. After lighting the third heater, the heat dispersion pattern was not different than with two heaters burning, and degrees of temperature rise also were very similar between 2 and 3 burning heaters. This lack of temperature rise and heat pattern improvement can be attributed to a change in wind velocity. The approximate wind velocity for 1 and 2 heaters burning was 5-10 miles per hour. A change was noted in the wind velocity about the time the third heater was lit. The wind increased to approximately 10-15 miles per hour with gusts going above 15 miles per hour.

The performance of the heaters in this test was very good in respect to the adverse weather conditions for heating. As the wind increases above 5 miles an hour the efficiency of under-the-tree heaters decrease (Bailey and Maxwell 1965). The wind conditions throughout the test

Table 1. Heat dispersion pattern and degrees (°F) increase obtained at the 5 foot level inside of heated trees over unheated trees by burning 1 under-the-tree petroleum wax heater.

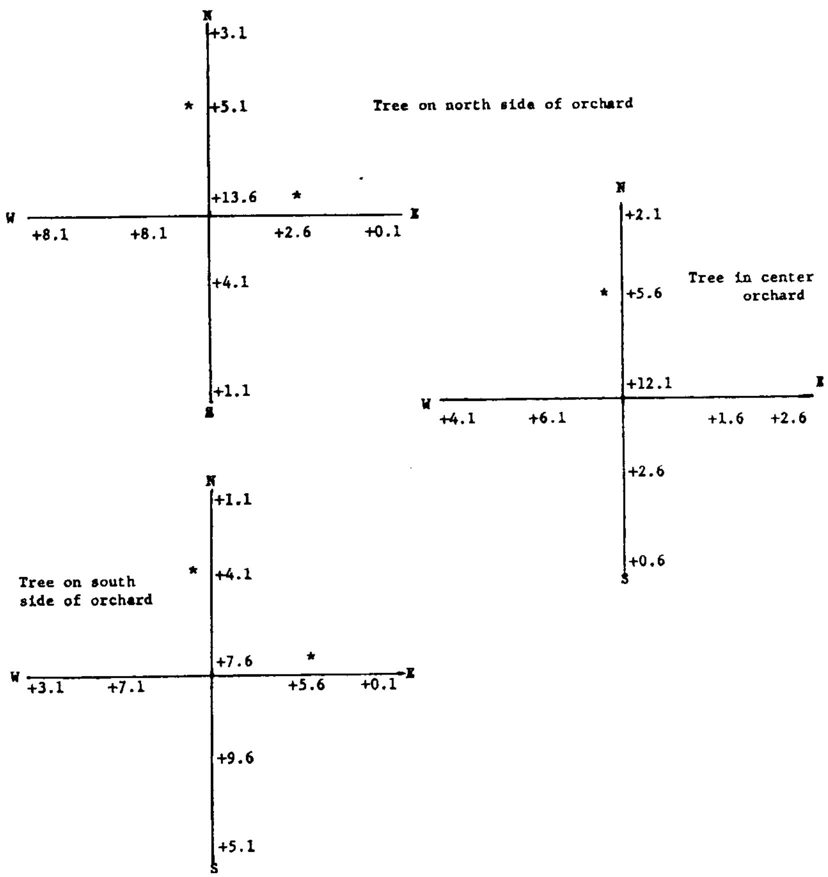


° Heater burning 3 feet from trunk; wind 5-10 miles per hour; wind direction east to southeast; ambient temperature 30.4°.

were rather high, but the trees being heated had very tight canopies that helped hold the heat inside the trees.

Table 4 presents the average temperature rise and heat dispersion patterns obtained in the three trees having thermometers in them. Table 5 gives the degrees temperature increase in the test trees in a 6 foot diameter circle at the 5 foot level and in a 12 foot diameter circle at the 5 foot level.

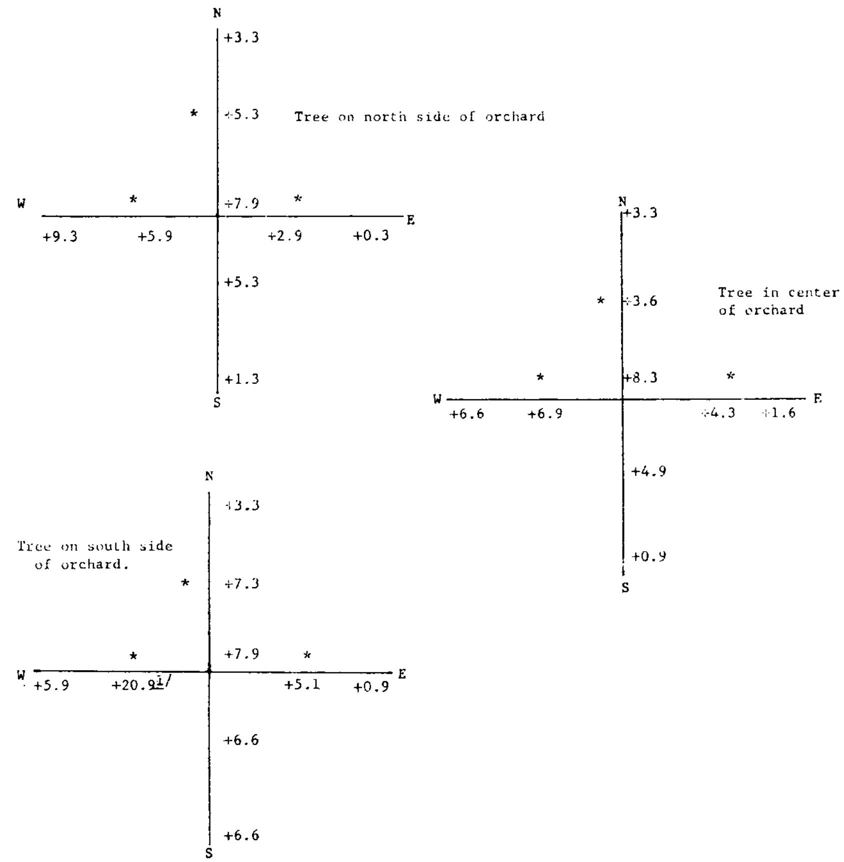
Table 2. Heat dispersion pattern and degrees (°F) increase obtained at the 5 foot level inside of heated trees over unheated trees by burning 2 under-the-tree petroleum wax heaters.



* Heater burning 3 feet from trunk; wind 5-10 miles per hour; wind direction east to southeast; ambient temperature 27.9°.

With 2 and 3 heaters burning there was an average rise in temperature of about 6° within the 6 foot diameter circle. Table 4 shows that within the 6 foot area the heat dispersion pattern is fairly uniform. The 12 foot diameter circle inside of the tree has an average rise of 4½ to 5° but Table 4 shows that outside of the 6 foot circle the heat dispersion pattern is not uniform. The high wind probably limited the effective heated area to about a 6 foot diameter circle in the center of the tree.

Table 3. Heat dispersion pattern and degrees (°F) increase obtained at the 5-foot level inside of heated trees over unheated trees by burning 3 under-the-tree petroleum wax heaters.

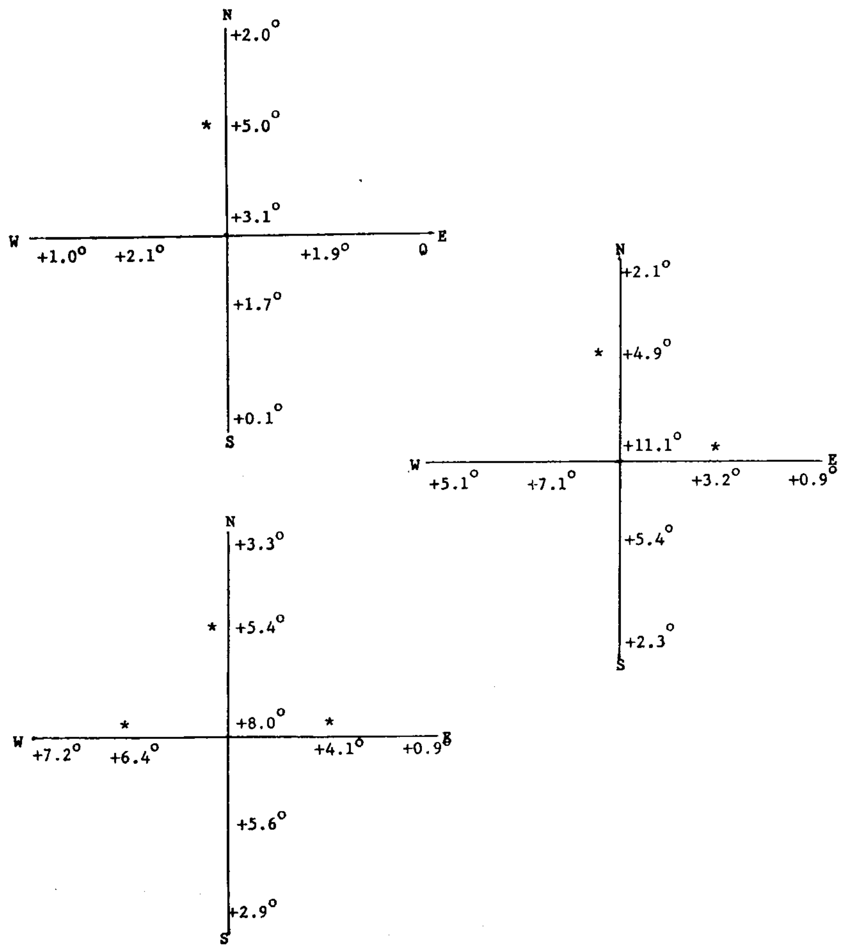


* Heater burning 3 feet from trunk; wind 10-15 miles per hour, wind direction east to southeast; ambient temperature 27.7°.

1 Thermometer probably directly over heater, 20.9° not used in compiling Table 4 and 5.

Most of the heaters lit very easily with a grove torch filled with one half gasoline and one half diesel fuel. In a few heaters the ignitor wick of paper was buried in wax and had to be relit. On several heaters the wax had pulled away from the side of the block to such an extent that the ignitor fuel did not burn on the surface but ran down the side of the block. The company engineer stated that these were problems that would be solved in the manufacturing process and heaters for commercial sale would not have these defects.

Table 4. Heat dispersion pattern and average degrees increase[1] (°F) of heated over unheated trees obtained by burning one, two and three under-the-tree petroleum wax heaters.



* Location of burning petroleum wax heater 3 feet from the trunk.
1 Clear, cold night with 5-15 miles per hour wind blowing from east to southeast. Ambient temperature 30.4°F to 27.7°F. Thermometers hanging inside the trees at the 5-foot level in the center and in all 4 quadrants 3 and 6 feet from the center of the tree.

The flame of the heaters was about 12-15 inches high. The wind was blowing hard enough so that they were probably burning at a slightly higher rate than 20,000 B.T.U.'s per hour. No damage was done to the trees or fruit by the flames except where a branch or fruit was hanging directly in the fire. The only damage then was to that portion in the fire.

Table 5. Temperature increase (°F) of heated over unheated trees in 6-foot circle inside of tree at the 5-foot level.

No. Heaters Burning	*Approx. wind velocity miles/hour*	*Tree North side of grove*	*Tree Center of grove*	*Tree South side of grove*	*Ave. Degrees Increase*
1	5-10	4.0°	3.0°	1.4°	2.8°
2	5-10	6.7°	5.6°	6.8°	6.4°
3	10-15	5.5°	5.6°	6.7°	5.9°

Temperature increase (°F) of heated over unheated trees in 12-foot circle inside of tree at the 5-foot level.

No. Heaters Burning	*Approx. wind velocity miles/hour*	*Tree North side of grove*	*Tree Center of grove*	*Tree South side of grove*	*Ave. Degrees Increase*
1	5-10	2.8°	2.1°	0.8°	1.9°
2	5-10	5.1°	4.1°	4.8°	4.7°
3	10-15	4.6°	4.5°	5.5°	4.9°

Clear night, ambient temperature 30.4°F - 27.7°F;
Wind direction east to southeast, velocity 5-15 M.P.H.
Size of heated area was 1 acre
Tree size 12 feet in diameter and 12 to 15 feet high
Tight canopies on trees and close to ground.

CONCLUSIONS

The results of this test indicated that 3 under-the-tree petroleum wax heaters burning at the rate of 20,000 B.T.U.'s each were effective under windy conditions of 10-15 miles per hour. The temperature was raised about 6 degrees in a 6-foot diameter circle at the 5 foot level. This amount of temperature increase would give protection to major limbs and the trunk during freezes that have occurred in the past in the Winter Garden and the Lower Rio Grande Valley.

The type of canopy on the tree will probably have a definite influence on the effectiveness of under-the-tree heaters. A tight canopy that extends close to the ground should be much more effective in holding heat within the tree than a more open canopy.

The degrees temperature rise obtained under freezing conditions was similar to the results derived from heating tests (Bailey and Maxwell 1965) under non-freezing conditions.

The experimental Sinclair Refining Company Heater performed in a similar fashion to other petroleum wax under-the-tree heaters (tested in 1965), burning at the rate of 20,000 B.T.U.'s per hour.

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Citrus Orchard Heating with Petroleum Coke Fuel[1]

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ABSTRACT

Petroleum coke fuel blocks were compared at various amounts to an acre. Burning 3 packages under each tree (1392 lb of fuel per acre) provided temperature increases at the center of the tree ranging from 5.5 to 13.5 F warmer than non-heated trees during the 5 hour period following ignition. Burning the same amount of fuel in the open, outside the tree skirts, provided temperature increases at the center of the tree ranging from 4.9 to 7.3 F warmer than non-heated trees during the 4-hour period following ignition.

Fuel blocks placed in the open, outside the tree skirts, were readily accessible to the lighters and could be ignited at the rate of 1300 units a man-hour, about 4 times the rate attained when blocks were placed under the trees.

INTRODUCTION

Following major freezes in the Texas and Florida citrus growing areas in 1962 several oil companies became interested in producing fuel packages that could be burned under the tree. Work with some of these experimental fuels has been reported (Young, et al., 1964; Bailey and Maxwell, 1965; Maxwell and Bailey, 1965; Leyden, et al., 1965; Miller, et al., 1966). This paper reports on tests conducted during the winter of 1965-66 comparing amounts of fuel and placement of fuel either under the trees or in the open between the trees.

MATERIALS AND METHODS

The petroleum coke fuel blocks, produced by Mobil Oil Corporation under the name "Tree-Heet", incorporated improvements developed as a result of field testing experimental blocks the previous year. Individual blocks weighed 2 lb. A pair of blocks was wrapped in wax-coated kraft paper then sealed in black polyethylene. The 4 lb package was designed to be burned as a unit. Burning rate studies of the units revealed them to be 70 to 80% consumed in 4 hours.

Test locations of 5 and 10 acres, with surrounding control areas, were instrumented with thermocouples in the manner previously described (Leyden, et al., 1965). There were 80 trees wired to measure

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center of the tree and adjacent thermometer stand temperature at the 5 ft level. There were 14 trees with thermocouples at the 10 ft. level within the tree. Trees in the test area were about 12 ft in height and 12 ft in diameter.

No nights of serious cold hazard occurred during the winter of 1965-66. Testing was conducted under less than freeze conditions. Weather data for 3 test nights being considered are listed in Table 1.

The amounts of fuel and the placement of the packages in the field scale tests were:

Location 1. (100 trees/acre, 5 acres heated)
5 January 1966 – 1200 lb fuel/acre, 3 packages under each tree
3 February 1966 – 800 lb fuel/acre, 2 packages under each tree

Location 2. (116 trees/acre, 10 acres heated)
15 January 1966 – 1392 lb fuel/acre, 3 packages under each tree
3 February 1966 – 1392 lb fuel/acre, 3 packages placed in the open, east, west, and northwest of each tree.

Fuel packages were ignited by using a conventional orchard heater liquid fuel torch.

RESULTS AND DISCUSSION

Temperature changes in the heated area relative to temperature changes in the control area are presented in Table 2.

With 800 to 1392 lb of fuel to an acre, burned under the trees, the average temperature increases at points within the tree, 5 and 10 ft above ground, were at least 4 F the first hour after ignition. Temperature increases reached a peak 2 or 3 hours after ignition with at least 5 F being maintained through the fifth hour. Greater temperature increases were found with the greater amounts of fuel.

Temperatures at thermometer stands adjacent to the trees approached those at the center of the tree and a thermometer so placed was found to be a useful indicator of tree temperature (Leyden, et al., 1966).

Table 1. Weather data during test periods 1966, Weslaco, Texas.

Date	Cloud cover (tenths)	Wind speed (mph)	Wind direction (from)	Temperature[a] F 5 ft	Temperature[a] F 30 ft	Relative Humidity (percent)
5 January	0.5	0.5-1.5	SW	52 to 47	52 to 48	80-90
15 January	0.1	0.2-0.5	S	49 to 42	49 to 47	80-90
3 February	0	0.1-0.2	SE	39 to 35	46 to 39	80-90

[a] Within Cotton Region Shelter outside of heated area at start and end of test period.

Table 2. Differences in temperature changes between heated and non-heated areas during tests with petroleum coke fuel blocks.

Date	Amount of Fuel (lb/A)	Amount of Fuel (pkgs/tree)	Location of fuel	Hours after ignition of fuel 1	2	3	4	5
				(ave. temperature increase F°)				
				Center of tree 5 ft level				
3 February 1966	800	2	under the tree	4.6	5.5	6.9	6.1	5.5
5 January 1966	1200	3	" " "	5.1	8.8	11.1	9.4	8.6
15 January 1966	1392	3	" " "	5.7	13.4	8.8	6.7	5.7
3 February 1966	1392	3	between the trees	7.3	6.5	6.2	4.9	2.6
				Center of tree 10 ft level				
3 February 1966	800	2	under the tree	4.0	5.0	5.1	7.8	7.3
5 January 1966	1200	3	" " "	6.2	10.0	12.3	10.5	7.3
15 January 1966	1392	3	" " "	5.3	10.3	7.4	4.8	5.0
3 February 1966	1392	3	between the trees	5.5	4.4	2.6	3.3	1.0
				Thermometer stand 5 ft level				
3 February 1966	800	2	under the tree	2.7	4.6	4.1	2.8	2.9
5 January 1966	1200	3	" " "	5.3	6.8	8.5	7.2	7.8
15 January 1966	1392	3	" " "	4.5	12.4	7.7	7.2	5.7
3 February 1966	1392	3	between the trees	7.5	7.5	6.3	4.3	2.4

° Calculated as: (temperature heated area t_n – temperature heated area t_o) – (temperature control area t_n – temperature control area t_o)

One of the difficulties encountered with small heat sources placed under the tree has been the labor requirement involved in lighting. In the 1964-65 tests 1 man-hour was required to ignite 430 units. In the 1965-66 tests tree skirts, with an additional year's growth, were more fully developed making fuel packages placed under the tree a little more difficult to locate. To ignite 2 or 3 packages under a tree the lighter had to enter the tree at more than one point. Under these conditions the labor requirement was about 1 man-hour to an acre.

Placing fuel blocks outside the skirt of the tree offered a means of speeding up the lighting process. Men igniting fuel packages placed outside the skirts could proceed down the row at a fast pace. As many as 1300 units were ignited in 1 man-hour. With 116 trees to an acre and 3 units a tree, placed in the open, 4 acres were ignited in about 1 man-hour.

Comparing equal amounts of fuel burned under the trees or in the open outside the skirts, the greatest temperature increase did occur when the fuel was burned under the tree. However, 1392 lb of fuel to an acre, burned in the open, provided a temperature increase at the 5 ft level in the center of the tree ranging from 7.3 F the first hour after ignition to 4.9 F at 4 hours.

From a practical standpoint the labor requirement for ignition must be considered along with the temperature increases reported. The greater temperature increase from placement under the tree as compared to placement in the open may be offset by the greater labor requirement: 1 acre a man-hour versus 4 acres a man-hour.

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New Insulating Materials to Protect Citrus Trees from Freezing[1]

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ABSTRACT

The increased use of a wrap of insulating material to protect citrus tree trunks against freeze injury has encouraged the introduction of several new materials for this purpose. Three of these, a fiberglass building-insulation batt, a polyurethane foam pad, and a wrap of aluminum-lined corrugated cardboard ("Air-flow" Tree Protector) were tested along with the fiberglass wrap currently used. The tests are conducted on small two-year old orange trees in an artificial cold chamber. The ratio of the rates of change of the bark temperature under the bank to the outside air temperature, bark/air ratio, provided a standard for comparing the insulating value of the different materials. While a precise relationship between post-freeze tree recovery and the bark/air temperature term could not be established from these tests, the results, supported by past experience, suggest that freeze injury risk would likely occur if the bark/air ratio exceeded .55. A practical application of the bark/air term is proposed.

INTRODUCTION

The idea of protecting citrus trees with a wrap of inert insulating material was introduced in the Valley by Rohrbaugh in 1956. These wraps, usually referred to as "permanent banks", proved very effective in the 1962 freeze and have gained increased usage (Leyden and Rohrbaugh, 1963). The original "permanent bank" consisted of a 4 inch-thick jacket of rock wool supported by a roofing paper covering (Leyden, 1957). Later an improved bank of fiberglass insulation batts supported by a section of chicken wire was developed (Hensz, 1965). Recently several new materials have been introduced for use as tree banks. Like the fiberglass now used the new materials have distinct economic and practical advantages over the older soil banking system. The insulating ability of three new materials and the fiberglass bank currently used at the Texas A&I Citrus Center were tested and compared. The test results are reported here.

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MATERIALS AND METHODS

The banking materials tested are shown in Fig. 1 and described below:

Material	*Description*	*Ave. Thickness, Installed*
Owens-Corning Fiberglass Building Insulation	2 x 24 x 48" batt (pink colored)	4.0 in.
Polyurethane foam padding	a) ca. 1 x 19 x 35" batt b) ca. ½ x 19 x 50" batt	3.6 in. 2.25 in.
"Air-flow" Tree Protector F-D-S Mfg. Co., Pomona, Calif.	14 x 20" aluminum foil covered piece of corrugated cardboard	.75 in.
Owens-Corning "TWF" Fiberglass*	four 1 x 19 x 24" batts (white colored, cut from 1 x 24 x 50" roll)	4.0 in.

* The "TWF" fiberglass, currently used for permanent banks at the Citrus Center, served as the standard of comparison for the new materials.

Small, 2-year old sweet orange trees on sour orange rootstocks in 5 gal. glazed crocks were used for the tests. The varieties, principally Jaffa, Valencia, and Washington navel, were randomly selected for the different tests. The cold chamber, a Labline constant temperature cabinet, had a temperature range from 5 to 95°F., a manual thermostat, and accommodated one 36" high tree. Trees were selected to meet height limitations without heavy pruning. Temperatures were measured with a Leeds and Northrup Model 8692 temperature potentiometer using copper constantan thermocouples as the sensing elements. The thermocouples located: 1) in the soil ball, 6 in. deep, 2) on the bark surface, under and 6 in. from the top of the bank, 3) in the center of the leaf canopy, and 4) in the air, about mid-tree height. The readings from thermocouples at locations 3) and 4) were averaged to get the air temperature.

Part of the tests were conducted in July, August, and early September 1965; the rest in December, 1965 and January and February, 1966. Though we conditioned the summer-test trees with a 2-day cooling regime to harden them before the freeze tests, they undoubtedly were not as dormant as the winter-tested trees. The trees were also treated with various freeze-protectant materials relative to a coincident experiment. These factors and the variability in freezing rates between individual tests, permitted only the most general comparisons of post-freeze growth responses. The air temperature curves in Figs. 2a and 2b show the approximate temperature regimes used for the summer and winter tests. Individual tests deviated from these curves mainly in the rate of

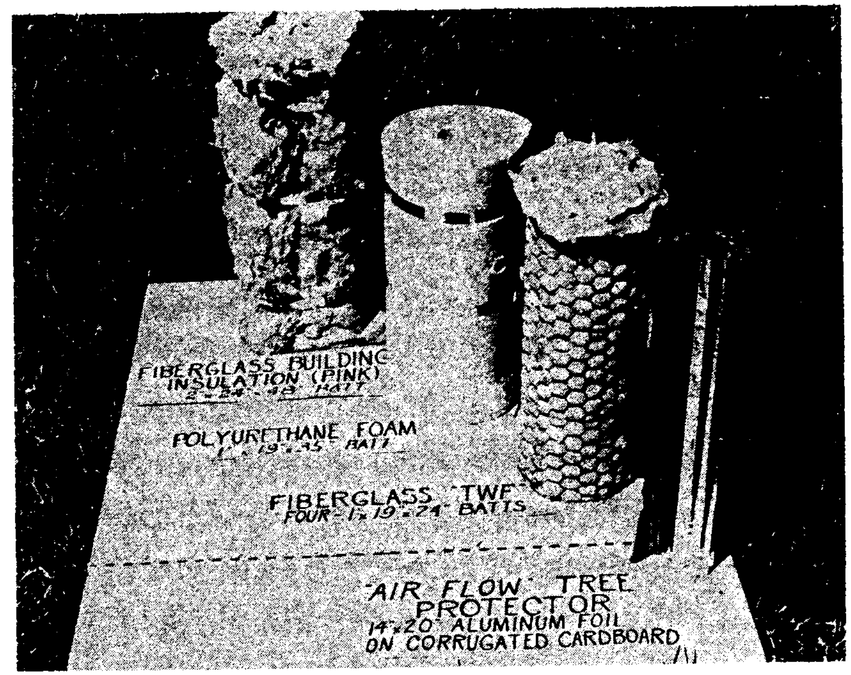

Figure 1. These materials are currently used in the Valley as wraps around citrus trunks to protect them against freezing. Their insulating abilities were tested and compared at the Texas A & I Citrus Center.

temperature decreases and the duration of the freezing period. The ranges in these values are given in Table 1. These regimes somewhat typify the 1951 and 1962 freezes.

After removal from the cold chamber, the trees were kept indoors one or two days then transferred to a shade house. Observations on freeze recovery were made when the trees had 3-4 in. of new shoot growth.

The dissimilarity between tests, while creating certain statistical problems, did provide a wide range of conditions for evaluating the banking materials. To make meaningful comparisons, we sought to characterize the insulating value of the banking materials with a term which would be constant under a wide range of freezing conditions. The ratio of the rate of change of the bark temperature to the rate of change of the air temperature proved a reasonable choice for such a term. As shown in Fig. 2, each test included two major temperature drops. This provided two estimates of this ratio of the rates of change of bark to air temperature, hereafter abbreviated bark/air term, for each experiment. The other calculations shown in Table 1 involved standard statistical methods (LeClerg, Leonard, and Clark, 1962).

RESULTS AND DISCUSSION

The curves in Figs. 2a and 2b exemplify the air and bark temperature relationships. Differences in insulating value of the four materials would be indicated by differences in the slope of the bark temperature curve. Since the slope is the rate of change of the bark temperature, these differences will also be reflected by the bark/air term, shown in Table 1. The lower a material's bark/air term the better it insulates. A

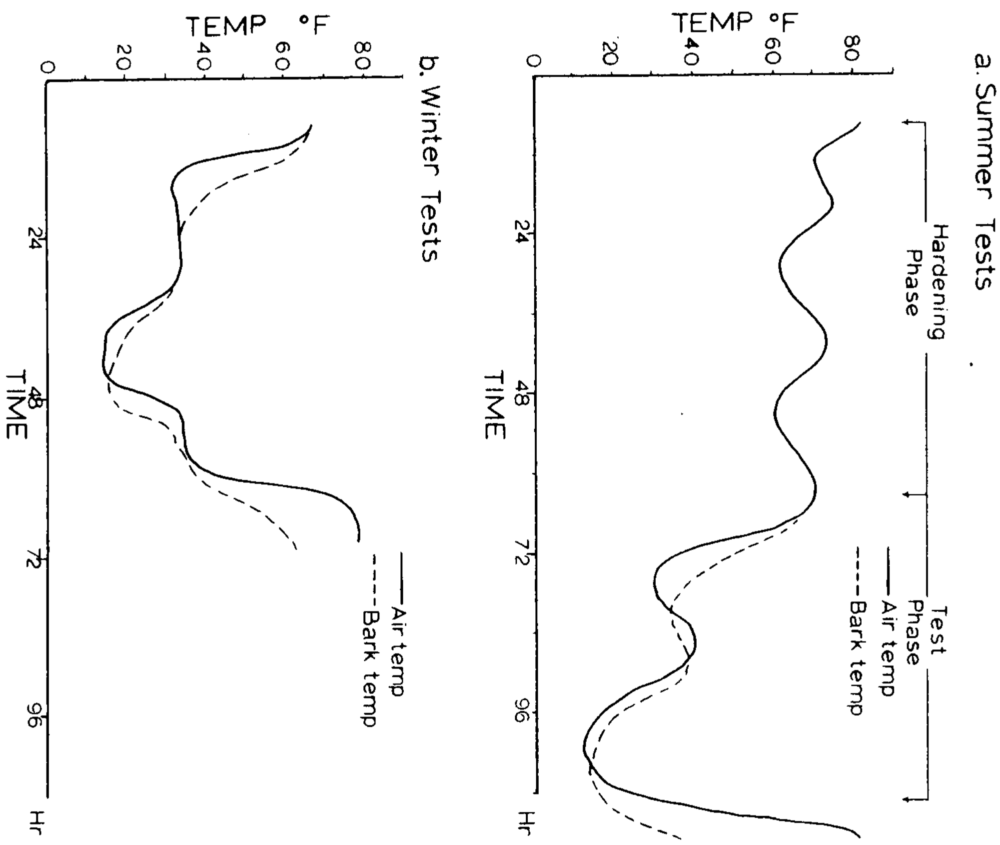

Figure 2. Representative curves of the air temperature and bark temperature under the bank for (a) summer test series and (b) winter test series.

Table 1. Conditions and results of tests of four permanent banking materials used for citrus tree freeze protection.

	Minimum Temperatures		*Duration Min. Temps.*		*Rate Temp. Change*		*Bark Rate*	*No. tests*	*Standard*
					Air	*Bark*	*Air Rate*	*Run*	*Deviation*
	(°F.)		(hrs.)		—°F/hr	—°F/hr			
	Range	Ave.	Range	Ave.					
Fiberglass (pink) Building Insulation	14-19	17.5	2½-15	7.8	17.7	6.0	.34	3	±.13
Polyurethane Foam									
1"X	13-19	16.9	2½-8	5.3	9.4	4.2	.45	4	±.09
½"X	12-14	12.2	14-25	20	10.7	4.4	.41	2	±.05
"Air-flow" Tree Protector									
Top Open	12-15	13	8-10	9	8.2	6.3	.76	2	±.10
Top Closed	6	6	6	6	6.8	3.3	.52	1	±.08
Fiberglass (TWF)	14-17	15	2-3	2.5	21.4	6.2	.29	2	±.01

ratio of 1.00 would indicate no insulating value at all. From Table 1, then, TWF fiberglass with a bark/air term of .29 appears to offer the most insulation and "Air-flow" Tree Protector, with a .76 bark/air term, the least. The standard deviation, in Table 1, provides a measure of the constancy of the bark/air term. Since the two bark/air estimates for any individual test were very similar, large deviations were the result of variations between tests of the same material. Slight differences in ther-mocouple placement vis a vis the bank probably exerted a dispropor-tionately great effect. The effect of an air gap between trunk and bank, for example, can be seen from the "Air-flow" bark/air data. When the top of this wrap was squeezed tightly around the trunk, the bark/air term decreased by 32%.

Because of the variation between test conditions and the other factors affecting post-freeze tree response, we could not determine what might be called the "critical" bark/air value. Such a value could pre-sumably serve to separate effective from ineffective banking materials. The influence of the dormancy status of the trees was very evident. Trees tested in the summer were killed 5 to 14 in. below the tops of the banks, while the winter-tested trees were killed only 0 to 7 in. below the bank tops. Seventy-five percent of the summer-tested trees and 83 percent of the winter-tested trees survived.

The coefficient of correlation between the bark-/air term and the temperature at the beginning of the freezing cycle was .290, which was not significant. The correlation between the bark/air term and the rate of air temperature decrease had a coefficient of −.446. The near sig-nificance of this latter coefficient at the .05 level justifies the suspicion that the bark/air term may tend to increase when air temperatures are falling at the rate of 1-2°F./hour.

With a hard freeze threatening, the bark/air term could be used to forewarn of possible trunk injury. With the appropriate bark/air term known, the air temperature and the time when the temperature begins descending on a hard freeze course must be obtained. The rate of air temperature decrease is then established by periodic half-hour or hourly measurements and the rate of temperature decrease under the bank is calculated by multiplying the bark/air term by the rate of air tempera-ture decrease. The last step is to obtain the interval between the time the temperature started falling to the time the bark temperature will reach some critical value, say 23°F. (Young, et al., 1963) by dividing the difference between 23°F. and the temperature at the beginning of the freeze period by the rate of bark temperature decrease.

Example: At 6:00 P.M. the air temperature is 35°F. By 10:00 P.M. the air temperature has fallen at a steady rate of −2°F./hr. to 27°F. If the trees are banked with a material which has a bark/air term of .50, the bark temperature is decreasing by .50 × −2°F. = −1°F./hr. At this ratio the bark temperature will reach 23°F. in 35° − 23° + 1°/hr. = 12 hrs. or around 6:00 A.M. if conditions remain unchanged. At this point the air tempera-ture would be 11°F.

From these tests and the performance of permanent banks in the 1962 freeze, we'd expect that trees banked with a material having a bark/air term above .55 would likely suffer some trunk injury during a severe freeze. Conversely, a material with a value of less than .45 would probably provide adequate protection for most situations. Further tests are necessary to affirm the constancy of the bark/air term and its use in judging a banking material's effectiveness.

CONCLUSIONS

While all four of the materials tested had some insulating ability, direct comparisons in terms of tree response were complicated by dis-similarities between individual tests. This variability, however, pro-vided a wide range of conditions for evaluating bank performance. One measure of the insulating value of the bank was the ratio of the rate of change of the outside air temperature. This figure, called the bark/air term, was reasonably constant over a wide range of conditions and provided a means of comparing the different banking materials. The bark/air term could be used to estimate when critical bark temperatures might occur during an actual freeze. From past experience and these tests, we could anticipate a severe freeze would cause some trunk injury on trees banked with a material having a bark/air term greater than .55.

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Protecting Soil Banked Citrus Trees with Fungicidal Paints Against Infection by Soil Fungi

Bailey Sleeth[1]

ABSTRACT

Fungicidal tree banking paints were effective in preventing infection by soil organisms of trunks of young citrus trees, which had been banked with soil to prevent freeze damage during the winter months. All paints were mixed in water and applied with a paint brush. No trunk infections occurred in 744 citrus trees treated with paints in which the copper content varied from silghtly less than 1 percent to 3 percent. The copper compounds used were copper oxide, tribasic copper, tetra copper calcium oxychloride (Copper A), and Bordeaux mixture. Of 123 trees painted with captan (N-(Trichloromethyl) thio-4-cyclohexene-1, 2-dicarboximide) 8 percent of the tree trunks were infected. The addition of 0.5 percent insecticides, chlordane, dieldrin or heptachlor or 90 percent inert clay did not impair the effectiveness of the copper containing paints.

It has been a common practice for many years to bank young citrus trees with soil to protect the trunk above the bud union as well as the lower scaffold branches against freeze damage in the Lower Rio Grande Valley. Soil is placed in a cone-shaped mound around the trees in late November or early December and removed in late February or early March when the occurrence of a damaging freeze has past. Within recent years there has been an increase in the use of permanent tree banks, which consists of fabricated insulating materials such as rock or glass wool to protect the tree trunk. The principal difference in the two types of banks is the length of time they are kept in place around the banked trees. The soil banks are in place for only 3 or 4 months of the year while the permanent fabricated banks remain in place for several years. The value of using soil banks to protect young citrus trees against total freeze damage was dramatically demonstrated in 1951 and 1962 when severe freezes occurred in the Valley.

There are certain hazards involved in banking citrus trees other than freezing, which can be avoided or greatly minimized if precautionary measures are taken. These hazards are damage to the tree trunk ranging from slight injury to killing the banked tree by pathogenic soil fungi, ants or termites, mechanical injury in building and removing the banks and the inadvertent use of plant toxic chemicals as arsenic in the tree banking paint. The extent of injury from these causes vary from

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year to year and usually are related to poor tree banking practices or adverse weather conditions.

Valley growers have been concerned for some 30 years or more with the hazard of fungus infection and damage in soil banked trees. Godfrey (1953) reported several different fungi in decayed bark lesions on banked citrus trees of which *Fusarium*, *Rhizoctonia* and *Sclerotium rolfsii* were the most common. *Phytophthora* is probably the most common cause of infected lesions on citrus tree trunks, especially those occurring at or slightly above ground level, in Valley citrus trees. Lesions caused by this fungus have tended to increase in Valley orange and grapefruit trees. However, the number of such infections has been relatively low and associated with unusually wet conditions around the affected tree. In one grove with permanent banks, in which the lower part of the banks was saturated with water, the incidence of infected trees was quite high. Olson (1951) reported that *Phytophthora* was the cause of tip blight of citrus seedlings in the nursery bed, and Waibel (1951) estimated 1,000,000 seedlings were killed in 1950 by this disease. Lined out sour orange nursery seedlings, occasionally, have been seriously damaged by this fungus.

The disease hazard to banked trees is related to (1) the presence and number of pathogenic organisms in the banked soil, or in the soil at the base of permanently banked trees; (2) environmental conditions, high temperature and moisture around the trunks of banked trees, which are favorable for fungus growth and trunk infection; (3) trunk injuries such as pruning wounds or mechanical injuries from hoes, shovels and mechanized equipment that provide an entry point for pathogens, if not protected with a wound paint; and (4) any condition that adversely affects the growth and vigor of the tree. It is obvious that the pathogen is the most important factor in the disease hazard. – no parasitic fungi, – no infected trees. In most Valley soils the number of pathogenic organisms present at banking time is probably too low to be a serious hazard for the first few weeks following banking. However, during the winter banked trees may become infected, if favorable conditions for infection occur and the trees are unprotected with an effective fungicidal banking paint.

The relative infrequency of trunk infections in banked citrus trees, either painted or unpainted, has raised the following questions: (1) is there an actual need for fungicidal tree paints, and (2) if needed what is the most effective and economical paint? Work was begun in the early 1950's in an attempt to answer these questions.

PROCEDURE

Trunks of young citrus trees were painted with commercial tree banking paints or laboratory formulated paint mixes, prior to banking with soil, over a period of several years, 1954-64. The basic fungicides were copper (copper oxide, tribasic copper sulfate, tetra copper calcium oxychloride), neutral zinc and captan (N-(trichloromethyl) thio-4-cyclohexene-1, 2-dicarboximide). In one test carbolineum was used. Insecticides (chlordane, dieldrin, heptachlor) were added to the paints for protection against ant and termite damage. The packaged commercial paints contained 90 percent inert materials and clay was added to most of the laboratory mixes. The primary purpose of the clay was to give body to the water mixed paint and visible evidence of application, – tree trunks with a white-washed appearance. The amount of active fungicidal chemicals in the water mixed paints varied from 0.5 to 4.0 percent. In most instances the active chemicals were around 1.0 percent for the fungicides and 0.5 percent for the insecticides.

The paint treatments were applied with a brush a day or two before the trees were banked in late November or early December. Each paint treatment was applied systematically to single tree plots in a block and repeated in the same order in subsequent blocks. An unpainted tree was left in each block for a check.

Nursery trees, 1 to 3 years old, in rows were used in most of the banking tests. Also, a number of young grapefruit and orange plantings, which the grower had painted and banked, were kept under observation to check on field effectiveness. The nursery trees consisted of grapefruit and orange budded trees as well as sour orange and Cleopatra mandarin seedlings. Soil banks varied from 15 to 20 inches in height. Both clean soil and trashy soil were used in separate blocks of trees.

In one test a high soil moisture content was maintained by irrigation which supplemented the rainfall during the winter. Within limits both good and poor tree banking practices were used to determine the effectiveness of fungicidal paints over a wide range of conditions.

RESULTS

The copper-based tree banking paints were the most effective treatments in preventing trunk infections of soil banked trees, table 1. No bark infected lesions occurred on the trunks of 744 trees protected by the paints containing copper. Of 123 trees treated with captan-based paint 8 percent had infected lesions. Two of 29 trees treated with a neutral zinc paint and 1 tree of 22 treated with carbolineum (arvenarius) were infected. The number of infections, 6 percent, in the unpainted controls was slightly lower than for the captan treatment. The lesions dried out and healed over with little or no damage to the trees.

The lowest concentration of metallic copper, 0.8 percent, in the applied paint was as effective in preventing infection as were the higher concentrations of 1.0, 1.7, 2.3 and 4.3 percent. Since captan was used only at the 1 percent level no data was obtained on its effectiveness at 2 or 3 percent levels. It is possible that at higher levels captan might have given better control of trunk infections. There apparently was no difference in copper source, as Bordeaux mixture, copper oxide, tribasic copper sulfate and copper A, all gave equally good results.

In 1956-57, there were 7 times more infected lesions in the trashy

soil banked trees than in the clean soil banked trees. In other tests there was little or no difference in the number of lesions when the trees were banked with clean or trashy soils.

No injury from insects occurred in any of the tests. The insecticides added to the different paints apparently did not reduce the effectiveness of any of the fungicides. The use of insecticides in the banking paints was considered good insurance against possible damage from ants and termites that might have been present in sufficient numbers to cause injury.

The addition of inert clays, up to 90 percent of the dry packaged commercial banking paints, apparently did not enhance the fungicidal properties of any of the paints. The clays did add bulk and served as a marker for trees painted. On the other hand the addition of clays to a paint would make it difficult if not impossible to use a sprayer to apply the paint rather than a brush.

DISCUSSION AND CONCLUSIONS

The importance of protecting young citrus trees against cold damage with soil banks in the Lower Rio Grande Valley has been well established. On the other hand the need for painting the tree trunks with a fungicidal paint has not been so well determined. Results of banking paint experiments, Table 1, and lack of grower reports of trunk injury in recent years indicate that the infection hazard has not been serious. If certain precautions are observed, trunk damage can be kept at a minimum, or avoided, if clean, nontrashy. soil is used and the banks are taken down in late February or March when the danger of freezing weather is past. On the other hand if trashy soil is used in the tree banks

Table 1. Summary of fungicidal tree banking paints used to protect the trunks of soil banked citrus trees from infection by soil fungi.

Date of tests	*Basic type paints used, trees treated and number infected*							
	Copper-based paint		*Captan-based paint*		*Others*		*Control*	
	Trees		*Trees*		*Trees*		*Trees*	
	Total	*Infected*	*Total*	*Infected*	*Total*	*Infected*	*Total*	*Infected*
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
1954-55	89	0	....	....	22	4	24	17
1955-56	120	0	30	0	....	....	....	....
1956-57	201	0	76	10	29	7	94	14
1958-59	34	0	17	0	....	....	17	0
1961-62	262	0	....	....	....	....	130	0
1963-64	38	0	....	....	13	0	12	0
	744	0%	123	8%	64	5%	277	6%

and they are not removed until late in April or early May, trunk infections may occur. The probability of infections will increase if banks are kept wet by rains or irrigations.

Since there is the possibility of trunk infections by soil pathogens and damage from insects in banked trees. many growers will undoubtedly continue to use tree banking paints to minimize or eliminate these hazards. The best paints evaluated were those containing copper, and its use in tree banking paints is recommended. The amount of metallic copper in a paint might well vary from less than 1 to 3 percent or more without injury to the banked tree, but there is seemingly no advantage in using paints with more than 1 percent copper. A Bordeaux mixture or neutral copper paint of 1 percent copper can be applied with a brush or a sprayer. Spraying would save considerable time over brush application. In either case the materials should be stirred frequently to keep the copper compounds from settling out.

For maximum protection against disease infection of soil banked citrus trees the following should be observed: (1) prune sprouts and paint cuts and wounds with a good wound protection paint (Sleeth, 1959); (2) apply a 1 percent copper-based paint to tree trunks with brush or sprayer; (3) use clean nontrashy soil for building banks and (4) remove soil banks by March 1.

Growers who plan on using a paint containing copper have a choice of several materials. To make a 1 percent copper containing paint with one of the following compounds: to 2 gallons water add 5 oz. tribasic copper sulfate (53%); or 6 oz. copper A (45%); or 3.3 oz. copper oxide (80%); or for Bordeaux mixture dissolve 10 oz. copper sulfate in 1 gallon water and mix with 10 oz. hydrate lime that has been suspended in 1 gallon water. Other neutral copper spray compounds may be used. They should be mixed in sufficient water to give a 1 percent metallic content in the applied paint. An insecticide should be added to give protection against ants and termites.

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Indications of Resistance of Texas Citrus Mites to Tetradifon (Tedion)[1]

H. A. Dean and Clifford E. Hoelscher[2]

Tetradifon has been used in the Lower Rio Grande Valley of Texas for the control of Texas citrus mites, *Eutetranychus banksi* (McG.), since 1959. The long-residual control of tetranychid mites with tetradifon made this material particularly useful for growers in a mite-control program at post-bloom. This mite increased to a greater population level following post-bloom than at any other period of the year (Dean 1959). After continued usage at post-bloom for 3-4 years, in certain experiments, tetradifon gave ineffective control in 1965.

During the early years of use, effective control was obtained where tetradifon was applied at post-bloom each year for 1 to 3 years. Texas citrus mites were in very small numbers following post-bloom application through August of 1959, 1960 and 1961 in an experiment at Weslaco (Bailey and Dean 1962). Similarly, Texas citrus mites averaged 0.1 and 0.08 mite per leaf in July 1960 and 1961 following post-bloom application in April in an experiment west of Mission (unpublished). In another experiment west of Harlingen mite populations were less than 0.6 mite per leaf in late August 1960 following application in April (Dean and Bailey 1963). In other experiments during this early period, tetradifon gave longer residual control of this mite than with other materials used.

Research investigators in California and Florida have reported ineffectiveness of certain acaricides against the citrus red mite, *Panonychus citri* (McG.), after continued usage. Resistance of citrus red mite to demeton and parathion applied to lemon trees was reported in California (Jeppson et al. 1958). Resistance in citrus red mite to demeton and tetradifon occurred after 3 to 5 applications under field conditions in California (Jeppson et al. 1962). Control of citrus red mite with tetradifon deteriorated after the fourth application in Florida (Johnson 1962).

MATERIALS AND METHODS[3]

Spray materials were applied from a ground rig with a single ex-

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[3] Thanks to Niagara Chemical Division, Rohm and Haas Company, Geigy Chemical Corporation and Union Carbide Chemicals Company for supplying various pesticides.

ception of May 23, 1961, in a Texsun grove east of Edinburg when a speed sprayer was used. Single nozzle guns (6/64 orifice size) were used with 550-600 psi pressure at the tank. Trees were sprayed from each quadrant position and from above with a tower gun to accomplish the desired coverage.

Texas citrus mite populations were determined from 40-leaf samples collected from the 4 trees in each plot. In the Texsun experiment, all treatment plots were treated alike at post-bloom and consisted of 5 treatments replicated 5 times. Counts from the 25 plots were averaged because only slight differences were found. At the Rio Farms experiment, the treatments were replicated 4 times. The mites were brushed from the leaves with a mite-brushing machine by a standard procedure and counted under a stereoscopic microscope. Scheduled summer treatments in these experiments prevented the collection of extended residual control data. The following spray materials were used:

a. Tetradifon – 25% WP and 12.3% EC.
b. Dicofol (Kelthane) – 18.5% EC.
c. Chlorobenzilate – 25% WP, 25% EC and 50 E.
d. Zineb – 75% WP
e. Carbaryl – 80% WP

Dosages indicated in the text and tables refer to the above materials in 100 gallons of spray mixture.

RESULTS

Greater mite populations were found prior to treatment at the Rio Farms experiment in 1963 than in 1964 or 1965 (Table 1). After 21 days in 1963, the wettable powder tetradifon treatment had reduced the population considerably, but the population increased to the pre-treatment level during the next 30 days. The addition of 1 pint dicofol gave added initial control to the powder and liquid formulations of tetradifon. Dicofol at 1 quart gave the best control of large populations.

The wettable powder formulation of tetradifon gave excellent control of Texas citrus mites for 57 days in 1964 when the initial populations were small.

Mite populations were increasing prior to application of the 2 formulations of tetradifon in 1965. The liquid formulation gave much better initial control after 34 days, but mites had increased after 57 days to greater population numbers in both treatments indicating ineffective control.

Great populations were present prior to treatment at the Texsun experiment in 1961 (Table 2). Application of 10 lb WP sulfur with 0.5 lb tetradifon applied from a speed sprayer resulted in excellent control 44 days later and on an intermediate date not shown.

Tetradifon was not used in the Texsun experiment during 1962 because of the absence of mites following the January freeze. An increas-

Table 1. Spray treatments applied to Valencia orange trees at a Rio Farms grove and their effects on Texas citrus mite populations.[a]

	A		B		C		D	
Date	*TCM*[b]	*TCME*[c]	*TCM*	*TCME*	*TCM*	*TCME*	*TCM*	*TCME*
4-8-63	17.35	30.90	16.85	33.25	19.82	39.20	20.68	35.52
4-9	1 lb 25% WP tetradifon + 1 lb zineb + 1.25 lb 80% carbaryl		1 quart EC tetradifon + 1 pint dicofol + 1 lb 25% chlorobenzilate		1 lb 25% WP tetradifon + 1 pint dicofol + 1 lb zineb		1 quart dicofol + 1 lb zineb	
4-30	.59	1.10	.01	.01	.01	.05	.02	.05
5-30	17.80	33.10	.60	1.10	.30	.50	.02	.10
3-17-64	–	–	.01	.02	–	–	–	–
4-8	1 lb 25% WP tetradifon + 1 lb zineb							
6-2	.08	.06	.10	.20	.08	.03	.01	.04
3-18-65	1.91	2.51	.48	.49	3.60	3.06	2.74	1.25
4-6	1 lb 25% WP tetradifon + 1 lb zineb				1 quart tetradifon + 1 pint 50E chlorobenzilate			
5-10	23.69	25.72	15.11	30.54	1.45	1.55	1.00	1.68
6-2	18.59	9.10	34.88	18.90	26.65	23.33	20.95	11.68

[a] 1963 data has been published, but is given for the convenience of the reader (Dean and Bailey 1964).
[b] Texas citrus mites per leaf
[c] Texas citrus mite eggs per leaf

ing population was found prior to treatment in 1963; so, dicofol was added. Lack of residual control of mites became apparent after 58 days.

In 1964, a smaller initial population was under excellent control 27 days later. Residual mite control was lost prior to June 30, 76 days after application.

In 1965, a small initial population was found just prior to treatment. On February 22, demeton had been applied for aphid control at 1 pint 26.2% E per 100 gallons mixture. No mite population record was made until 54 days after application of tetradifon since previous work had shown that expected populations would not have reached the level found on June 28, 1965. Indications of resistance were evident. It was interesting that four different oil fractions gave extended residual control of this mite when applied 3 days after the June 28 count (Hoelscher and Dean 1966).

ABSTRACT

The lack of effective residual control of Texas citrus mites with tetradifon following the third and the fourth annual treatment applied in 1965 indicated resistance had developed at 2 test locations. The liquid formulation resulted in better initial control than the wettable powder formulation, but during the second month after treatment, ineffective control was found with both formulations.

Table 2. Spray treatments applied at a Pineapple orange experiment east of Edinburg and their effects on Texas citrus mite populations.

Date	*Mites per leaf*	*Eggs per leaf*
5-17-61	17.95	21.80
5-23	.5 lb WP tetradifon + 10 lb WP sulfur + 1 lb zineb	
7-6	.02	.04
4-1-63	2.87	4.18
4-23	1 lb tetradifon + 1 lb 25% WP chlorobenzilate + 1 pint dicofol	
6-20	1.55	1.77
4-6-64	.06	.06
4-15	1 lb WP tetradifon + 1 pint 50 E chlorobenzilate	
5-12	.02	.05
6-30	6.33	7.81
4-26-65	.21	.28
5-5	1 lb WP tetradifon + 1 quart 25 EC chlorobenzilate	
6-28	23.20	31.38

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Texas Leaf-Cutting Ant: Damage to Citrus and Control[1]

Approved as TA 5532

REX B. REINKING[2]

ABSTRACT

The Texas leaf-cutting ant and damage caused to citrus is described. Control was achieved with applications of a pelleted bait containing Mirex, (dodecachlorooctahydro-1,3,4-methano-2H-cyclobuta(cd) pentalene). Treatment with bait was safer to trees and more economical than methods formerly used.

The Texas leaf-cutting ant is rusty brown body color and bears a number of spines on the head and thorax, which distinguishes it from the so-called Texas harvester ant. Size of this ant may vary from the soldier caste of ½ inch to a small worker that may measure only 1/16 inch in length. A number of queens may be present in a single colony. This ant does not sting, but it can bite; however, the bite is not painful.

Principal damage caused by this ant is in defoliating plants. To gather food for their underground fungus gardens the ants strip plants of foliage and buds. Earlier investigators (3) were of the opinion that the underground fungus gardens were the ants' sole source of food. However, it has recently been noted that when ants were fed a dyed bait the dye could later be found throughout the digestive tract and in the post-pharyngeal glands (2). Dye was also found in non-foraging workers, indicating a direct transfer of food between individuals. A nest of the leaf-cutting ant may consist of a few mounds, or may cover an area of several thousand square feet, and extend downward into the soil to a depth of 15 feet.

During 1965 a serious infestation of the Texas leaf-cutting ant developed in a citrus orchard northwest of Edinburg, operated by Carl and Robert Baney. Grapefruit and orange trees were completely denuded of foliage and many fruits were partially eaten by the ants (Fig. 1-3). Some trees died as a result of the damage. Control with methyl bromide gas was attempted but the citrus trees did not tolerate the gas and several trees were killed. Control with applications of 10% chlor-

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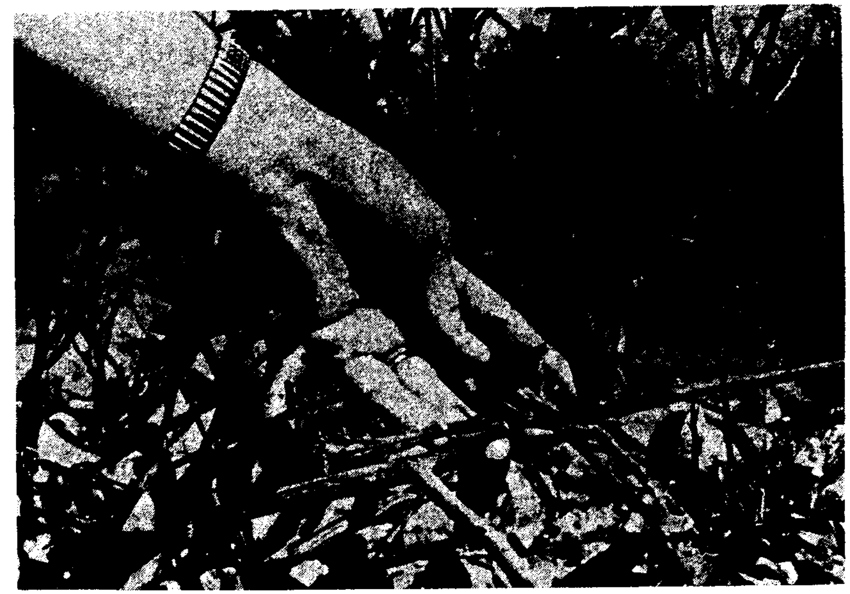

Figure 1. Grapefruit tree defoliated by Texas Leaf-Cutting ant.

Figure 2. Citrus fruit partially consumed by Texas Leaf-Cutting ant.

Figure 3. Texas Leaf-Cutting ant "town" in citrus orchard.

dane dust was not satisfactory as the infestation reappeared in a short time.

An attempt was then made to control the ants with a pelleted bait containing Mirex, (dodecachlorooctahydro - 1,3,4 - methano-2H-cyclobuta(cd) pentalene), a chemical used extensively for the control of imported fire ant, plus 8.5% once-refined soybean oil and citrus pulp as a base. Sixty-five mounds in the orchard were treated with 2 grams of the bait per mound on February 10, 1965. A check of the mounds on February 16 revealed that the bait had been removed from mounds where ants were feeding but not from mounds where ants were only excavating. A second check, on February 23, revealed all treated mounds had become inactive while untreated mounds remained active. Ants were relatively inactive throughout the summer in all mounds.

Heavy reinfestation occurred in the fall and 108 mounds were treated with approximately 5 grams of Mirex per mound on November 10, 1965. Examination on November 19 revealed all treated mounds inactive and untreated mounds still active.

These results indicate that control of the Texas leaf-cutting ant may be achieved by the use of a pelleted bait containing Mirex. This bait is economical and safer to citrus trees than methods formerly used. Studies

in Louisiana indicate the bait has no adverse effect on wildlife.

For a medium-size nest or "town" (one having a central nest area containing about 150 mounds) use 1 pound of the commercial material, "Mirex Pelleted Bait 450". For single-mound nests use 3 grams (approximately 1 teaspoon full).

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The Response of Soft Scale[1] and its Parasites to Repeated Insecticide Pressure

W. G. Hart, S. Ingle, M. Garza and M. Mata[2]

ABSTRACT

Aerial applications of methyl parathion, malathion (technical and dilute), azinphosmethyl (concentrated and dilute), and carbaryl were applied to a heavy infestation of brown soft scale (*Coccus hesperidum* L.) on citrus. Methyl parathion caused a pronounced increase in the scale population; all other materials were suppressive. Parasites continued to appear in the grove as long as significant numbers of scale were present, despite the repeated use of the pesticides.

INTRODUCTION

The use of ethyl and methyl parathion in and around citrus groves is believed to have caused brown soft scale (*Coccus hesperidum* L.) to change from a relatively minor pest to a major problem on 3 separate occasions in recent years. Bartlett and Ewart (1951) in California and Annecke (1959) in South Africa reported that the increased infestations of brown soft scale were indirectly related to within-grove applications of organophosphorus insecticides such as parathion. Also, drift of methyl parathion from cotton sprays is generally considered to be at least a contributing factor (Reinking 1964) to the outbreaks of brown soft scale in the Rio Grande Valley.

The reports of previous effects of organophosphorus compounds prompted us to investigate the impact on the brown soft scale and its parasites of sub-control doses of a number of insecticides currently used to control citrus pests.

MATERIALS AND METHODS

The tests were conducted in Hargill, Texas on a 320-acre citrus grove which was divided into four 80-acre test plots. Before our testing began, the grower had applied methyl parathion to the entire grove for control of the spirea aphid (*Aphis spiraecola* Patch). After this treatment, an extremely heavy buildup of brown soft scale developed.

Stearman planes were used to apply both dilute and technical formulations. The technical material was delivered with 6 No. 80015 flat

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tip nozzles at a pressure of 30-35 psi. The dilute materials were delivered with 24 T-jet nozzles (12 No. 6 and 12 No. 8) at a pressure of 30 psi. All the materials were applied at tree top height between each row of trees. Doses were designed to put heavy pressure on the population without controlling it.

In the 1st test, we applied technical malathion (undiluted) to plot 1 and emulsifiable malathion and emulsifiable methyl parathion at a dilution of 1 pt to 3 gal of water to plots 2 and 3. All materials were applied at a dose of 2 lb of actual toxicant per acre. The 4th 80-acre plot was used as the control.

In the 2nd test, started 25 days after the 1st, the 2 treatments with malathion were repeated, and carbaryl was substituted for methyl parathion in plot 3 to halt the rapid development of scale there. The carbaryl was applied at a rate of 2 lb of actual toxicant per acre diluted in 3 gal of water. Because of an error in nozzle arrangement, the technical malathion was applied at a rate of 3 lb actual toxicant per acre.

A 3rd aerial application was made with undiluted azinphosmethyl at a rate of ¾ lb actual toxicant per acre (plot 1), emulsifiable azinphosmethyl at 1 lb actual toxicant per acre diluted in 3 gal of water (plot 2), and carbaryl as before. These materials were applied 46 days after the materials in the 2nd test. The 4th plot was again used as a control, but shortly after the 3rd application, the scale in plot 4 reached such high levels that the grower was advised to spray the plot. Azinphosmethyl, carbaryl, and oil were therefore applied by ground sprayer (Econ-O-Mist®)[3] to plot 4 six days after the 3rd test began.

Weekly estimates were made of scale populations during each test by collecting 20 leaves from each of 60 trees in each plot. The leaves were taken to the laboratory, and the number of scale per leaf were counted. The number of parasitized scale was also recorded, and percentage parasitism was calculated. Counts of scale and parasites were continued for 3 months after the last spray to check the prolonged effect of the insecticides.

RESULTS

In the 1st test (Table 1), both formulations of malathion suppressed scale populations, and methyl parathion caused a rapid increase. Emulsified malathion had the greatest effect; a 61% reduction in live scale 7 days after spraying. This reduction compares with a 19% decrease in the check plot and a 20% increase in the plot treated with methyl parathion. Although a decline in parasitized scale occurred and some collections yielded no parasites, parasites continued to appear throughout the observation period after the treatment. *Coccophagus lycimnia* (Walker) was the predominant species of parasite collected.

[3] Mention of a proprietary product does not necessarily imply endorsement of this product by the USDA.

In the 2nd test (Table 2), carbaryl produced the greatest reduction in scale, and emulsified malathion again was more effective then technical malathion. The maximum effect of all 3 materials was observed 14 days after spraying. Emulsified malathion kept the scale below pre-spray levels for 28 days and carbaryl for 35 days. Parasites continued to appear throughout the test period and increased significantly 28 days after treatment. Although the rate of increase of the parasites was much greater in the check plot, it occurred there at the same time as in the treated plots.

When the 3rd test was. started, the pre-spray scale counts were considerably higher than in the previous tests. However, the results of this test (Table 3) were obscured because it was necessary for the grower to apply azinphosmethyl, carbaryl, and oil with ground equipment to the control plot shortly after the aerial sprays were applied. The combination of aerial and ground sprays rapidly brought the scale under control in all plots, but parasitism continued at a high level and remained high as long as scale were present in significant numbers.

CONCLUSIONS

Within-grove aerial applications of methyl parathion appeared to cause explosive buildup of brown soft scale, but sub-control doses of malathion, azinphosmethyl, and carbaryl had pronounced suppressive effects. The response of brown soft scale to methyl parathion was rapid, and the effect persisted for at least 2 weeks.

Parasites were found in the groves as long as significant numbers of scale were present, despite repeated applications of the pesticides.

Table 1. Effect of aerial applications of insecticides on brown soft scale. Test 1, July 1, 1965.

		Post spray population and % change[1]					
		7 days		*14 days*		*19 days*	
Plot	*Pre-spray scale per leaf*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*
1. Malathion (technical)	2.2	1.44	−34.5	3.2	+45.0	6.4	+191.0
2. Malathion (emulsion)	2.6	1.01	−61.2	2.1	−19.3	7.0	+169.0
3. Methyl parathion	1.85	2.21	+19.5	4.68	+153.0	10.1	+446.0
4. Check	2.1	1.71	−18.6	2.6	+24.0	7.3	+248.0

[1] From the pre-spray level.

Table 2. Effect of aerial applications of insecticides on brown soft scale. Test 2, July 26, 1965.

		Post spray population and % change[1]											
		7 days		*14 days*		*21 days*		*28 days*		*35 days*		*42 days*	
Plot	*Pre-spray scale per leaf*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*	*Scale per leaf*	*% change*
1. Malathion (technical)	6.4	6.3	−1.6	3.9	−39.1	5.3	−18.0	5.6	−11.9	19.0	+196.0	18.9	+195.0
2. Malathion (emulsion)	7.0	5.9	−15.7	3.4	−51.5	4.2	−40.4	13.2	+89.0	9.2	+30.9	16.4	+135.0
3. Carbaryl	10.1	3.7	−63.4	2.8	−72.3	5.2	−48.5	5.4	−46.9	7.3	−27.4	12.1	+19.8
4. Check	7.3	7.8	+6.8	8.9	+21.9	11.0	+50.6	18.1	+148.0	22.0	+201.0	17.7	+143.0

[1] From the pre-spray level.

Table 3. Effect of aerial applications of insecticides on brown soft scale. Test 3, September 9, 1965.

Plot	Pre-spray scale per leaf	Post spray population and % change[1]					
		7 days		14 days		20 days	
		Scale per leaf	% change	Scale per leaf	% change	Scale per leaf	% change
1. Azinphosmethyl (concentrate)	18.9	4.3	−77.4	3.1	−83.6	1.4	−92.7
2. Azinphosmethyl (dilute)	16.4	5.7	−65.1	3.0	−81.6	0.4	−97.8
3. Carbaryl	12.1	2.4	−80.2	3.2	−73.6	0.9	−92.6
4. Check	17.7	7.3	−58.9	1.8	−90.0	0.5	−97.4

[1] From the pre-spray level.

ACKNOWLEDGEMENT

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The Brown Soft Scale, *Coccus hesperidum* L. (Hemiptera: Coccidae), in Citrus Groves in Rio Grande Valley

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ABSTRACT

Surveys of brown soft scale (*Coccus hesperidum* L.) conducted in selected citrus groves of the Rio Grande Valley from 1962 through 1965 showed that the intensity of the infestation lessened in 1965 and that the population peak that year occurred later in the season than in previous years. The influence of drift of methyl parathion from applications on adjacent fields is still evident. Also the present predator-parasite population complex may not be able to cope with adverse environmental effects, which may partly explain the continuing severe infestation of brown soft scale.

INTRODUCTION

An unusual buildup of brown soft scale (*Coccus hesperidum* L.) in the Rio Grande Valley first became generally apparent in 1959 (Dean et al. 1962) after a severe infestation, indicative of what was to follow, was noted in a grapefruit planting near Raymondville, Texas in 1957 (Reinking 1964). Outbreaks of a similar nature were reported from California by Bartlett and Ewart (1951) and from South Africa by Annecke (1959). Although these authors attributed the problems in those areas to within-grove applications of parathion for other pests, in citrus groves of the Rio Grande Valley we have considered the drift of methyl parathion from widely interspersed cotton plantings as the source of difficulty. The evidence to support this was strengthened by the occurrence of the largest population of scale in the midvalley area where cotton and citrus plantings are most widely interspersed.

Since early 1962, monthly surveys of brown soft scale have been conducted in the Rio Grande Valley citrus groves from Roma to Brownsville to determine the extent of the biological outbreak and the subsequent population trends of the scale and the parasites presumed to hold it in check.

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SURVEYS

When the surveys were begun in early 1962 after a severe freeze, the scale population was at a very low level. At that time, 31 groves from Roma to Brownsville were observed monthly. This number was gradually reduced to 20, the number currently surveyed, because the significant information could be obtained from the groves selected: 7 groves are now surveyed in the west valley from Roma to Edinburg, 7 groves are located in the midvalley from East Edinburg to Adams Gardens; and 6 groves are in the east valley from Olmito to Brownsville.

The initial surveys of population trends of the brown soft scale and its parasites were based on observation of infested trees in the field; after October 1963, the method presently used of bringing leaves into the laboratory and counting the number of scale per leaf was begun. Records of the abundance of scale, parasites, and predators are made each month.

PARASITES AND PREDATORS

Early observations revealed that *Coccophagus lycimnia* (Walker) was the most abundant parasite (85-99% of all collected) of the brown soft scale in the Rio Grande Valley. Other parasites that occur commonly are *Microterys flavus* (Howard), *Encyrtus bicolor* (Howard), and *Aphycus* sp. A summary of parasites found to date is shown in Table 1.

Predators of the brown soft scale found in the area include the coccinellids *Chilocorus cacti* (L.), *Hippodamia convergens* Guerin, *Thalassa montezumae* Mulsant, and *Olla abdominalis* (Say). Also active in the groves are the lacewings, *Chrysopa bimaculata* McLacklan, and *C. rufilabris* Burmeister.

Table 1. Parasites associated with *Coccus hesperidum* L. in Rio Grande Valley citrus groves.

1. *Aphycus maculipes* Howard
2. *Aphycus* sp.
3. *Aphycus flavus* Howard
4. *Encyrtus* sp.
5. *Coccophagus lycimnia* (Walker)
6. *Coccophagus flavifrons* Howard
7. *Microterys flavus* (Howard)
8. *Microterys* sp.
9. *Cheiloneurus* sp.
10. *Aneristus youngi* Girault
11. *Anicetus annulatus* Timberlake
12. *Aphycus pulvinariae* Howard
13. *Cheiloneurus albicornis* Howard
14. *Encyrtus bicolor* (Howard)
15. *Encyrtus infelix* (Embleton)

The parasites *Coccophagus cowperi* Girault, *C. scutellaris* (Dalman), *Encyrtus lecaniorum* (Mayr), and *Coccophagus* sp. which were introduced from Israel, and *Aphycus luteolus* Timberlake, and *A. stanleyi* (Compere) which were introduced from California, do not at present appear to have become permanently established. Parasite introductions are continuing as a control measure and efforts are being made to modify the release procedures and to provide more suitable conditions for the introduced species.

EFFECTS OF PESTICIDE

The involvement of methyl parathion in the outbreak of severe brown soft scale in citrus groves in the Rio Grande Valley is amply demonstrated, and outbreaks can still be caused by applications of this pesticide. During the spring of 1965, 2 groves in Hargill, Texas were treated by the grower with methyl parathion for aphid control. A pronounced upsurge in scale followed these treatments, and the resulting infestations were the worst we encountered that year in the Rio Grande Valley. Continuing problems in areas subjected to the greatest drift of methyl parathion and a decline in the severity of scale during 1965 when ultra low volume sprays were used instead of conventional sprays also implicate methyl parathion as a significant factor in the problem.

POPULATION TRENDS

Infestations of brown soft scale in 1965 increased later in the year to lower peak levels of abundance than in previous years (Fig. 1). The first evidence of significant increase in 1963 occurred in May; in 1964, it occurred in April; in 1965, a slight upswing appeared in June, but it did not become significant until July and August. The peak population of brown soft scale in 1965 occurred in October compared with August in 1964 and was only 38.8% as high as in 1964. However, the change in method of counting introduced in October 1963 meant that such a direct comparison of the populations before and after the change was not valid. The average number of scale per leaf is a more accurate method of estimating populations. In 1964, as late as November, an average 2.3 scale per leaf was found compared with 1.87 in 1965. Thus, the November value for 1964 was 23% higher than the peak production in 1965.

Evidence of effective activity of parasites against the brown soft scale was lowest in valley groves during the summer months, the period when most cotton sprays are applied and also the period of highest temperatures. In 1964, the percentage parasitism in survey groves (Fig. 1) started to decline in June and reached its lowest point in July; the first significant increase occurred in September, and highest percentage parasitism occurred in January. The following year, 1965, the number of parasites reached a low point in May, and none were recovered until September; thus in 1965 the increase in parasitism followed an upturn in scale population by 2 months. Effective activity of parasites was again highest in January.

DISCUSSION

Monthly surveys of Rio Grande Valley citrus groves indicate a tendency for the infestation of brown soft scale to decline in severity and for the peak population to occur later in successive years.

A rapid increase of scale in April 1964, coupled with a decline in parasitism that persisted until August, indicated that adverse conditions were effecting the parasites. The drift of aerial insecticides from cotton

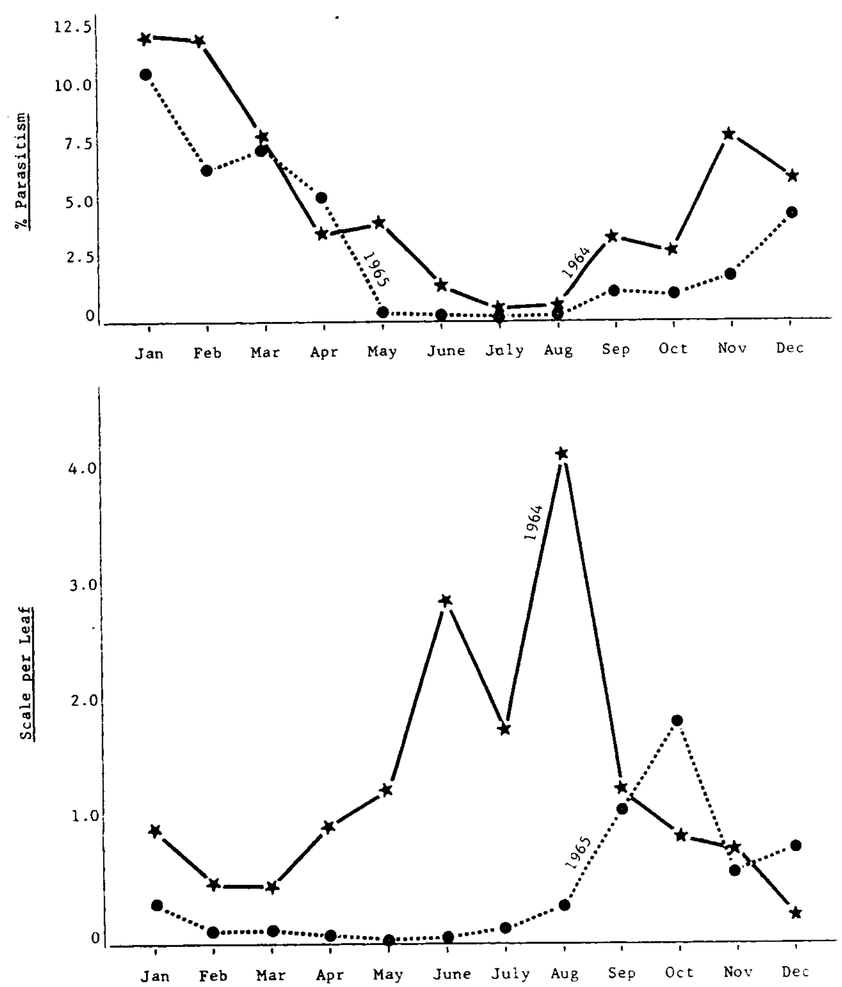

Figure 1. Mean percent parasitism and population trends of brown soft scale in 20 survey groves in Rio Grande Valley 1964-1965.

applications and the hot, dry weather are considered factors in this suppression.

During 1965 the scale populations remained low despite an apparent total absence of parasites during the 4 summer months. Parasites reappeared after rains ended a prolonged dry period and scale populations started to increase.

While the initial outbreak of brown soft scale can be traced to methyl parathion, the persistance of the outbreak, much longer than similar outbreaks in California or South Africa, indicates that the condition which caused the initial upsurge in population is still a factor or that the parasite-predator complex has been changed and the predominant entomophagous species now present are unable to cope adequately with local environmental conditions.

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Timing and Rate of Nitrogen Fertilizer Application for Texas Citrus Orchards[1]

Approved as TA 5532

R. F. LEYDEN[2]

ABSTRACT

Application of nitrogen fertilizer well before bloom (December-January) resulted in higher yields than did application in mid-February. With equivalent annual amounts of nitrogen no yield differences resulted from single or split applications. Yields were significantly lower where no nitrogen fertilizer was added. Between rates of 1 and 2 lb of nitrogen a tree a year there were no significant yield differences.

INTRODUCTION

The influence of nitrogen fertilizer on yield and tree vigor has been investigated in all citrus growing areas of the United States. With respect to the rate of application the more recent recommendations call for a lesser amount of nitrogen than formerly. In 1948 California workers suggested 2½-3 lb of nitrogen a tree a year; in 1960 1½-2 lb (Platt, 1960). Florida recommendations, based on yield potential, included amounts up to 6 lb a tree a year in 1954 (Reitz, 1954). As revised in 1964 the recommendation states that 200 lb of nitrogen an acre a year is the maximum that will show benefit in most Florida orchards (Reitz, 1964). Stewart and Wheaton (1966), in a 5 year study with Valencia oranges in Florida, found 100 lb of nitrogen an acre a year resulted in significantly higher yields than the 50 or 300 lb rates.

The greatest nitrogen stress in citrus is exhibited at flowering and fruit set (Jones, 1960). At bloom, and immediately following, the nitrogen level in leaf tissue typically shows a sharp decline as nitrogen supplies are being concentrated in the reproductive tissues (Leyden, 1963). To insure an adequate supply of available nitrogen in the soil at bloom time recommendations from most citrus growing areas call for a late winter or pre-bloom application of nitrogen (Bailey, et al., 1963; Hilgeman, 1941; Jones and Embleton, 1958; Reitz, et al., 1964).

The nitrogen timing and rate studies reported here cover 2 crop years prior to the freeze of January 1962 in the Lower Rio Grande Valley. Variable freeze damage led to abandonment of the particular experimental sites. The data is presented with the realization that the time period involved is shorter than is desirable for nutritional studies.

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MATERIALS AND METHODS

An experiment involving timing of nitrogen fertilizer application was established on the L. J. Boggus orchard, north of Harlingen, in December 1958. The soil was a Hidalgo clay loam. Trees were Valencia orange on sour orange rootstock, approximately 10 years-of-age, spaced 20 x 25 feet. A latin square design with 6 treatments in 6 replications was used. Individual plots consisted of 3 rows of trees with 7 trees in each row. Yield records were obtained from the 5 center trees in the middle row. Nitrogen, as ammonium nitrate, was applied at the rate of 1½ lb of actual nitrogen a tree a year. The timing schedules were:

1. single application, all in December
2. " " " " January
3. " " " " February
4. split application, ½ December, ½ May
5. " " ½ January, ½ May
6. " " ½ February, ½ May

Application was made between the 15th and 30th of the month in each case.

In January 1960 a timing and rate of nitrogen fertilizer application experiment was established at the Citrus Center. The soil was Hidalgo sandy clay loam. Trees were Redblush grapefruit on sour orange rootstock, approximately 12 years-of-age, spaced 25 x 30 ft. A randomized complete block design with 4 replications was used. Individual plots consisted of 3 rows of trees with 4 trees in each row. Yield records were obtained from the 2 center trees in the middle row. The treatments were:

1. 1 lb of N a tree a year, all applied in January
2. 1 lb " " " " " " , 1/2 applied in January, 1/2 April
3. 1 lb " " " " " " , 1/3 applied in January, 1/3 April, 1/3 July
4. 2 lb " " " " " " , all applied in January
5. 2 lb " " " " " " , 1/2 applied in January, 1/2 April
6. 2 lb " " " " " " , 1/3 applied in January, 1/3 April, 1/3 July
7. No nitrogen applied

Application was made between the 1st and 15th of the month in each case. Duncan's multiple range test was used to determine the significance of yield differences between treatments in both experiments.

RESULTS

In Table 1 the yields in pounds a tree are presented for the Valencia orange experiment for 1960 and 1961. In 1960 greater yields were obtained from treatments having at least part of the fertilizer nitrogen applied in December or January as compared to treatments in which application was deloyed until mid-February. Differences were significant at the 5% level.

There were no significant differences between single and split applications.

In 1961 yield was greater from the treatment having all of the nitrogen applied in December than from the treatment having application delayed until February. Differences were significant at the 5% level.

No other comparisons showed significant differences.

Table 2 presents the yields, in pounds a tree, from the Redblush grapefruit experiment for 1961 and 1962. During both years all treatments which received nitrogen fertilizer produced greater yields than the treatment which received no nitrogen. The difrerences were significant at the 5% level.

There were no significant differences between the 1 and 2 lb rates of nitrogen or timing schedules in either year.

DISCUSSION

In the Valencia orange experiment yields were lower where application of nitrogen was delayed until mid-February as compared to applications made 30 and 60 days earlier. In both years the February application occurred about 2 weeks prior to full bloom. Before the establishment of the experimental treatments this orchard had received nitrogen fertilizer at the annual rate of 1 to 1½ lb of N a tree for several years. In spite of this history of regular nitrogen applications the data indicate that a yield advantage was realized by applying at least some of the nitrogen well before bloom.

In the Redblush grapefruit experiment at least a part of the year's supply of nitrogen was applied in early January to all except the no nitrogen treatment. The only significant differences in yield existed between treatments receiving nitrogen and the no nitrogen treatment. Between the 1 and 2 lb rate there were no significant differences. This orchard had received nitrogen fertilizer at the rate of 1 lb of N a tree

Table 1. Influence of timing of nitrogen fertilizer application on yield of Valencia oranges.

Timing schedule	Yield (pounds a tree)	
	average of 6 reps	
	1960	*1961*
1. All in December	104 a*	200 a
2. All in January	83 a	176 ab
3. All in February	51 b	152 b
4. ½ December, ½ May	88 a	176 ab
5. ½ January, ½ May	84 a	176 ab
6. ½ February, ½ May	48 b	144 b

* means followed by the same letter do not differ significantly at the 5% level.

Table 2. Influence of timing and rate of nitrogen fertilizer application on yield of Redblush grapefruit.

Timing schedule	Rate	Yield (pounds a tree)	
	(lb/acre)	average of 4 reps	
		1961	*1962*
1. All in January	1	370 a*	319 a
2. ½ January, ½ April	1	296 a	270 a
3. 1/3 January, 1/3 April, 1/3 July	1	396 a	318 a
4. All in January	2	375 a	273 a
5. ½ January, ½ April	2	338 a	331 a
6. 1/3 January, 1/3 April, 1/3 July	2	317 a	308 a
7. No nitrogen fertilizer applied	0	184 b	173 b

* means followed by the same letter do not differ significantly at the 5% level.

a year for several years preceding the experiment. Apparently the soil nitrogen level was not high enough to sustain yields in the absence of a regular annual application of nitrogen.

The general fertilizer recommendation for Texas citrus orchards calls for up to 2 lb of nitrogen a tree a year (Bailey, et al., 1963). The data reported here indicate a definite yield response from the application of 1 lb of nitrogen a tree a year on Hidalgo sandy clay loam but no additional response from the application of 2 lb. Dacus and Shull (1962) found no significant differences in yield between rates of from ½ to 3 lb of nitrogen a tree a year on Willacy fine sandy loam over a 4 year period. They reported that during the 3rd and 4th year all rates of nitrogen gave significantly greater yields than no nitrogen. In a 5 year experiment on Willacy fine sandy loam trees with no nitrogen applied from 1955 to 1960 were yielding as much in 1959 and 1960 as were trees that had received 3 lb of nitrogen a tree a year during this period (Maxwell and Shull, 1963).

CONCLUSIONS

Fertilizer recommendations provide only a general guide to the grower. They can never be specific for each individual orchard. While the soil in some orchards in the Lower Rio Grande Valley may be at a sufficiently high fertility level so as to show no yield response to nitrogen fertilizer for several years, observation suggests this to be the exception rather than the rule.

The experimental evidence available indicates that rates of nitrogen fertilizer on the order of 1 to 2 lb of actual nitrogen a tree a year are adequate in Lower Rio Grande Valley orchards, with the 1 lb rate satisfactory in most cases. All, or at least part, of the annual application of nitrogen fertilizer should be applied well before bloom. The period December-January is suggested.

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The Effect of Gibberellic Acid on Rind-Oil Spotting and Color Development of Marrs Oranges[1]

JOHN E. FUCIK[2]

ABSTRACT

Marrs orange trees were sprayed with gibberellic acid (GA) to reduce rind-oil spotting on early harvested fruit. The treatments, 5, 10, 20, and two 5 ppm GA sprays, were applied in early September. Dimethyl sulfoxide (DMSO), glycerine, and an anionic spreader-sticker were used as spray adjuvants with each GA treatment. GA retarded normal coloring of the fruit and this effect persisted on ethylene de-greened fruit. Rind-oil spotting appeared to increase at the higher GA concentrations. DMSO diminished the effect of GA on color development while the other adjuvants had no influence. Internal quality factors of the fruit were not affected by any of the treatments.

INTRODUCTION

Marrs oranges will pass Texas' maturity standards early in the fall and many are harvested when the peel is still quite green and physiologically immature. Growers and packers have found that the handling of this green fruit frequently results in a high incidence of rind-oil spot (oleocellosis). It is not ordinarily a problem when harvesting is delayed until later in the season.

Rind-oil spots apparently result from a reaction of the epidermal cells to peel oil which has been released from oil glands ruptured during harvest (Klotz, 1961). On ethylene-treated fruit spots are green at first but eventually turn purplish-brown with the area around the oil glands often slightly sunken. When badly affected, fruit cannot be marketed fresh. Preventative measures center on harvesting the fruit late in the day when its skin is dry and less subject to bruising (Johnson, 1961). Since this remedy is sometimes unsuccessful and often inconvenient, an alternative control would be of value.

Navel oranges harvested late in the season in California frequently deteriorate due to rind staining, a disorder similar to rind-oil spot. The peel of fully matured navel oranges apparently loses its resistance to mechanical abrasion. Spraying the trees with gibberellic acid (GA) can reduce rind staining (Coggins, et al., 1963). This growth regulator apparently retards the aging process in the rind. The "younger" rind can

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better resist mechanical abrasions which lead to rind staining (Coggins and Lewis, 1965). Because GA also delays color development, the California scientists recommend spraying only after the fruit has attained marketable color (Coggins and Eaks, 1964).

Early harvested Marrs oranges must be degreened with ethylene. Therefore, if GA could reduce rind oil spot it would be of little consequence if it also delayed color development, provided it did not prevent degreening with ethylene. The characteristics and physiology of the Marrs peel may interact with the Texas climate to produce a response to GA quite different from that of the California navel. These considerations justified an experiment using GA on Marrs oranges.

MATERIALS AND METHODS

The experiment was conducted in a 10-acre block of 4-year old Marrs oranges. The experimental trees were grouped in 4 adjacent rows and were separated by one or more non-treated trees within the row. The GA, a 10% soluble powder[3], was applied at 0, 5, 10, and 20 ppm concentrations. A spray adjuvant, dimethyl sulfoxide (DMSO) glycerine or an anionic dodecylbenzene sulfonate spreader - sticker ("Slick"[4]), was used with each GA treatment. The DMSO and glycerine were at 1% (v/v) concentrations and the "Slick" at .01% (v/v). The solutions were applied on September 9 with a 3 h.p. gasoline powered sprayer at the rate of about 2 gal. (8 liters) per tree.

The treatments were applied in the early afternoon. The temperature was 92 F., the relative humidity was 50%. One group of trees receiving 5 ppm GA was given another 5 ppm two weeks later. The five GA treatments combined with three spray adjuvants and two replications required a total of 30 trees. The experimental design employed a split-plot technique. The main plots were the GA treatments, the sub-plots were the three spray adjuvants. Statistical analyses followed those outlined by LeClerg, Leonard, and Clark (1962). Three fruit samples were taken: before treatment, 2 weeks and 6 weeks after the initial treatment. Each sample included four fruit per tree, one from each quadrant. All fruit was de-greened by commercial processors. After degreening, rind-oil spots were counted and their total area estimated. A Gardner Color Difference Meter was used to measure the ratio of green to orange color in the skin. Four color determinations per fruit were made. Quality evaluations of fruit size, % juice, and Brix were made on composite samples of the five GA treatment.

RESULTS AND DISCUSSION

In Fig. 1 the color differences resulting from the GA treatments are shown. The vertical scale provides a relative measure of rind color. The

[3] "Pro-Gibb" – a product of Amdal Co., N. Chicago, Ill.
[4] Mfg. by Starbar Div., Agric. Specialties, Dallas, Texas.

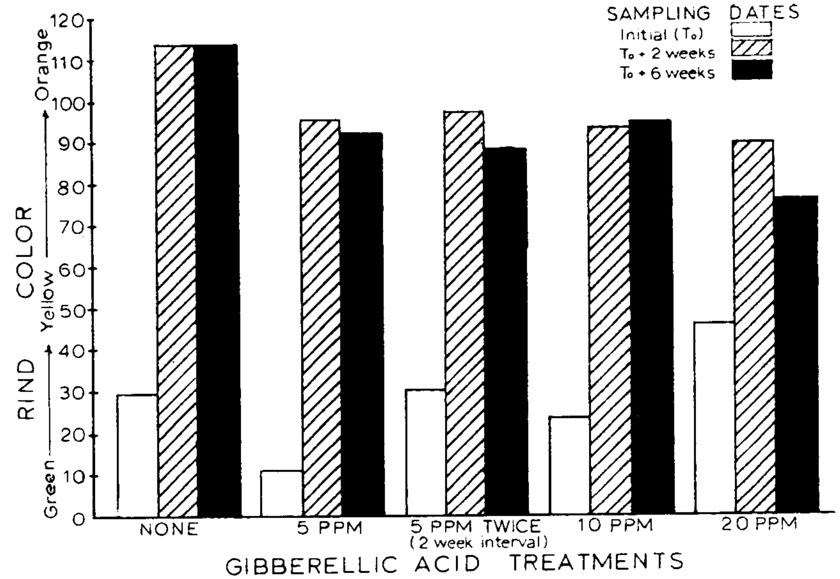

Figure 1. The effect of gibberellic acid on the rind color of Marrs orange.

GA sprayed fruit was significantly greener than the non-treated fruit for both the 2 and 6 week samples. Differences between GA concentrations were not significant for either sampling date. GA appears to have a long residual effect since the color changes between the 2 and 6 week samples were very slight. An exception may be the 20 ppm-treated fruit which appeared even greener after 6 weeks. This is consistent with the results obtained in California on navel oranges.

The spray additives significantly affected the color of the fruit sampled 2 weeks after treatment. This was primarily due to the DMSO which appeared to diminish the GA effect. The relative color values, ranging from light orange to greenish-yellow, were 102, 97, and 92 for DMSO, "Slick", and glycerine respectively. The 6 week samples evidenced a similar, but not significant, trend. Since DMSO is known to help materials pass through cell membranes, it could have increased GA translocation from the fruit thereby reducing the growth regulator's negative effect on color development (Keil, 1965). Further testing may substantiate this effect and determine its cause.

GA did not reduce the incidence of rind-oil spotting. Statistical analysis indicates that the higher GA concentrations actually increased both the number and area of the rind-oil spots (Table 1). It should be pointed out, however, that both the fruit harvesting and subsequent handling procedures may not have favored maximum rind-oil spot development.

Table 1. The effect of Gibberellic Acid (GA) on rind-oil spotting of Marrs oranges.

	Time Between Treatment & Fruit Sampling					
	2 weeks		6 weeks		Mean of Both Samples	
Conc. of GA (ppm)	No. of Spots	Area (mm^2)	No. of Spots	Area (mm^2)	No. of Spots	Area (mm^2)
0	2.0 b*	16 a	2.4 a	9 a	2.2 a	12 a
5	1.6 a	12 a	2.6 a	9 a	2.1 a	10 a
5 (twice)	2.2 b	18 a	3.4 a	19 a	2.8 ab	10 a
10	3.6 c	20 a	4.6 a	35 a	4.0 ab	28 b
20	4.1 d	46 a	4.4 a	34 a	4.2 b	40 c

* Values having the same letter suffix are not significantly different at the 5% level.

The juice quality of the fruit was not influenced by the GA sprays or the spray adjuvants.

ACKNOWLEDGEMENTS

Appreciation is expressed to: Amdal Company, Div. of Abbott Laboratories for the gibberellic acid; Mr. Henry Hensz, Harlingen, for the use of his orchard and trees; Burton Auto Supply for loan of the sprayer; the U.S.D.A. Fruit and Vegetable Products Lab. for use of the Gardner Color Difference Meter.

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Factors Affecting Acceptance of Grapefruit Drinks

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ABSTRACT

Results of taste analyses indicate adults as well as children preferred a grapefruit based berry flavored drink prepared from debittered or one-half debittered grapefruit juice. Sixth grade children preferred a low acid (0.5%) and high sugar (16° Brix) drink. A higher level of acidity (0.70%) was preferred by adults. Inter-relationships of pH, acidity, and sweetness of a citrus-berry flavored drink were investigated.

Storage temperatures above 68° F. caused rapid deterioration in flavor and color of the canned concentrate. Frozen storage is recommended. A pure fruit formulation consisting of late season grapefruit juice, lemon concentrate, strawberry puree and sugar was judged highly acceptable.

INTRODUCTION

There are many variations in taste preferences, yet there is an overall pattern of acceptance within which these preferences are experienced. It is recognized that there are national differences in food preferences, for example, the Mexican palate likes spicy food, the Germans like acid or pickled foods, and the French note flavor nuances which are of little concern to the English. It would appear that American preferences are being conditioned to blander, sweeter foods. Soft drinks, all sweetened with sugar or artificial sweeteners have upped their sales 64 percent in the last 5 years to a record $2.3 billion, or an estimated 227 bottles per person per year.

Orange juice remains a favorite beverage because it satisfies a large number of taste requirements. It is not very acid; it is sweet enough to appeal to children, yet not too sweet for adults; it has a pleasant aroma, a nice color, and a flavor that appeals to almost everybody.

Many people like the more pronounced flavor of good grapefruit juice, which is more acid, usually contains slightly less sugar, and has a tang or bitterness that is distinctive. Our experiences indicate that bitterness is acceptable within a rather narrow range, and that young people, especially children, prefer sweeter, less bitter juice than adults. In seeking to develop grapefruit flavored drinks having the widest possible acceptance, a number of studies were made on attributes (i.e., bit-

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terness, acidity, color, storage effects and flavors) known to influence consumer likes and dislikes.

The results of these taste panel tests were used in the formulation of grapefruit-berry-lemon drinks proposed as a possible additional outlet for grapefruit juice. Since this information is thought to have wider application than this specific development, it is reported in this paper.

BASIC FLAVOR PREFERENCE

A series of taste tests were conducted using children and adults to determine the preference for degrees of bitterness, sweetness and acidity for drinks containing grapefruit juice. Strawberry flavored grapefruit drinks (Lime, et al., 1962) were used in these tests. Three taste panels were used, consisting of (1) 55 adults, (2) 25 first grade children, ages 6 to 7, and (3) 24 sixth grade children, ages 12 to 13. *Bitterness*: Preference with respect to three levels of bitterness (normal, ½ debittered, completely debittered) was determined on drinks having equal sugar and acid content. The highest level of bitterness was obtained by using normal grapefruit juice (0.057% naringin) in the drinks. The lowest level of bitterness was obtained by using enzyme debittered juice (Griffiths, et al., 1963). An intermediate bitter level was obtained by blending equal amounts of debittered juice with normal juice.

Sweetness: Preference for sweetness was obtained from drinks having sugar contents of 10, 13 and 16%, acid and bitterness content being held constant.

Acidity: Drinks having three acid levels, 0.50, 0.70 and 0.90%, were used to determine acidity preferences. Acidity was adjusted to these levels using citric acid. Sweetness and bitterness were maintained at equal levels.

Three sets of drinks, bitterness, sweetness and acidity, each set consisting of three levels, low, medium and high of the factor under test, were prepared and presented to taste panel members. These sets were:

1. Bitterness. Drinks containing debittered, ½ debittered, and bitter grapefruit juice, all having 13% sugar and 0.90% acid.
2. Sweetness. Drinks containing 10, 13 and 16% sugar (Brix value), all having 0.90% acid and ½ debittered grapefruit juice.
3. Acidity. Drinks containing 0.50, 0.70 and 0.90% acid all contained 13% sugar and ½ debittered juice.

Taste panel members were asked to rank the three drinks of each set in order of preference, number 1 being the most desirable and number 3 the least desirable. Results of these tests are shown in Tables 1, 2 and 3.

PERCEPTION OF DIFFERENCES IN ACIDITY, pH AND SWEETNESS OF DRINKS

Investigation of formula variations in blended drinks indicates that pH as well as total acidity and sugar content is an important factor in flavor analysis. A taste panel of 14 adults was used to determine how much variation of acidity, pH and sweetness was necessary to cause a recognizable difference in the taste of a citrus drink. Presentation was by the triangle (two identical, one different) method and differences were considered significant when statistical analysis indicated an .05 level of difference. In each test, two of the three variables were held constant.

To determine the amount of difference in acid content of drinks necessary for detection by the taste panel, drinks were prepared and presented in the following manner:

Grapefruit based strawberry flavored drinks having acid contents of 1.0% and 0.9% and both having the same sugar and pH values were prepared and taste-tested. The experiment was repeated with drinks of 1.0% and .85% acid contents.

The difference in sugar levels of drinks necessary for detection by the panel was determined in the same manner by varying the sugar content in steps of 0.5% while keeping the acid and pH values constant.

Differences in pH values detectable by the panel were also determined by varying the pH while keeping the acid and sugar values constant. The pH values were adjusted by the addition of sodium citrate.

An indication of the interaction of titratable acidity and pH on flavor was obtained by selecting two drinks for taste testing having detectable flavor differences due to acid content (0.85 vs. 1.05). The pH of the high acid drink was increased in increments of 0.1 pH unit before each taste test. Table 4 lists the above variables.

INFLUENCE OF COLOR ON ACCEPTANCE BY CHILDREN

Color of completely "natural" drinks is determined by the ingredients, strawberry puree flavored drinks being pink, raspberry a light red, and blackberry a magenta color. The amount of color carried by juice from Texas Ruby Red grapefruit was insufficient to provide a desirable color to a "Texas Punch" drink foundation.

A comparison was made of the reaction of 145 first and second grade children when they were presented natural colored drink (a very light orange tint) and when the same drink was colored a bright red. The drinks were served from glass pitchers so that the colors could be plainly seen. The children were given approximately one ounce of each drink in a four ounce cup and told they could have a full cup of the drink they preferred. Both samples were given to the child in private so that his or her decision would not influence other children.

INFLUENCE OF TEMPERATURE AND TIME OF STORAGE ON ACCEPTABILITY OF GRAPEFRUIT-STRAWBERRY-ORANGE CONCENTRATE DRINK BASE

It is recognized that high temperature and length of storage have deleterious effects on citrus products. In order to determine the shelf life of citrus-based concentrated drinks, storage tests were run on a four-fold grapefruit-strawberry-orange concentrate. The drink base was heated to 185° F. in a tubular heat exchanger, filled into both plain and enameled cans, sealed, held for one minute and cooled in running tap water. The cans were stored at 0° F., 40° F., 68° F., and room (80-90° F.) temperatures for 7 and 14 months and then examined.

At the end of the storage periods, samples were reconstituted to 13° Brix and placed in glass beakers for color examination. For flavor evaluation, the drinks were presented in dark red glasses to a nine member taste panel and each member asked to rate the flavor. Ratings for color and flavor were on an 11 point hedonic scale, 10 being ideal, 5 acceptable and 0 repulsive. Figures 1 and 2 show results of these examinations.

ACCEPTABLE FORMULATIONS

In 1957, four flavor variations for Texas Punch were reported (Lime and Griffiths, 1957). The basic formulation was: sugar 2500 gms, citric acid 167 gms, sodium citrate 60 gms, vitamin C 1.5 gms, grapefruit juice 3850 ml. The four flavor combinations which were suggested are orange-pineapple, grapefruit-pineapple, orange-grapefruit and lemon-lime[2].

Because some of the ingredients were not readily available, several "home" formulations were developed which consisted of juices which could be found in any grocery store (Lime and Griffiths, 1962).

A successful formulation consists of two 46-ounce cans grapefruit juice, six 6-ounce cans lemonade sweetened frozen concentrate, two 6-ounce cans orange frozen concentrated juice, one No. 2 can of blackberries, or one package frozen strawberries, and 3 pounds of sugar.

For use, one volume of concentrate is diluted with 2½ volumes of water and ice. The above amount of concentrate makes approximately 6 gallons of punch.

It appeared desirable to develop a blend of pure fruit juices or mixes which could be processed commercially. By using a commercially available lemon concentrate it was found possible to formulate a grapefruit-berry-lemon-sugar mixture which could be canned as a four-fold concentrate and upon dilution made a very acceptable fruit drink.

A number of fruit and berry purees were tried (plum, peach, raspberry, blackberry, strawberry, naranjilla). Of these, the grapefruit-strawberry-lemon-sugar base appeared most promising for commercial success. It was also determined that juice expressed from grapefruit late in the season (February, March or April) was not sufficiently bitter to warrant debittering. Formulation and preparation of this base is as follows:

Single strength late season grapefruit juice	33.0 lbs.
Lemon concentrate, Calif. Sunkist, 37.4 Brix, 27.3% acid	5.6 lbs.
Strained strawberry puree (from 4+1 frozen berries)	11.9 lbs.
Sugar	35.2 lbs.

This makes approximately 8 gallons of concentrate. The mixture is pumped through a tubular flash tube pasteurizer at an exit temperature of 190° F., filled into 8-ounce enameled cans, sealed, cans inverted for one minute, then cooled in running tap water. Because of loss of color and flavor during room storage, these cans are preferably stored and marketed as a frozen product. For use, one volume of base is diluted with 3 volumes ice water. Brix of the punch (diluted) is 14.6°, acid is 0.71%.

RESULTS AND DISCUSSION

Basic flavor preference, Tables 1, 2, 3:

Both adults and sixth grade children showed a preference for drinks prepared from either one-half debittered or non-bitter grapefruit juice (Table 1). The preference for drinks using non-bitter versus one-half debittered was not nearly as clear-cut as between bitter and the other two. First grade children did not discriminate clearly enough between the three levels of bitterness for their results to be significant.

A very distinct preference on the part of first and sixth grade children for the sweetest drink (16° Brix) is noted in Table 2. With the adult group, the majority favored the middle level of sweetness (13° Brix) when the acid level was 0.70%. It is possible that if the acid level had been raised to 0.90%, more of the adult group would have preferred the 16° Brix drink.

The first grade children did not show a decisive preference for any of the three levels of acidity in the drinks offered them (Table 3). It is questionable if children of this age understand (semantically) the differences between acidity levels and bitterness levels which they were asked to discriminate. The sixth grade group were clear-cut in their preference for the drink having the lowest acid content (0.50%), whereas the adults were nearly as definite in preferring high, or at least moderate (0.90, 0.70%) acidity. If preferences expressed by the first

[2] Flavors used were Dodge and Olcott, Orange No. 404, Dodge and Olcott Lemon No. 402, Dodge and Olcott Grapefruit No. 401, Dodge and Olcott Lime No. 403, 5 ml. per flavor addition, Dodge and Olcott Pineapple No. 417, 10 ml. per flavor addition.[3]

[3] Use of a company and/or product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

graders in Tables 1 and 3 are omitted and those of the sixth grade combined with the adult scores, the group would appear to like best a drink made from debittered grapefruit juice having a Brix reading near 16° and an acid level of 0.50%. If the drink is to appeal to adults as well as the younger group, a bias toward the 0.70 level of acidity is indicated.

Perception of differences in acidity, pH and sweetness, Table 4:

The interplay of tartness, which is affected by a combination of acidity and pH, and sweetness as measured by total sugar content, is not well understood or very clearly defined. Within the limits of the formulations considered applicable in this investigation, a study was made of how much variation of acidity, pH, and sweetness is permissible before a detectable difference in taste of the drink is created.

In Series I, when acidity was changed with sugar and pH content,

Table 1. Bitter preference shown as percent of panel members preferring.

Bitter level	*1st grade*	*6th grade*	*Adults*
Non-bitter	44	44	52
½ bitter	24	39	34
Bitter	32	17	14

Table 2. Sugar preference shown as percent of panel members preferring.

Sugar content percent	*1st grade*	*6th grade*	*Adults*
10	20	5	16
13	20	5	49
16	60	63	36

Table 3. Acid preference shown as percent of panel members preferring.

Acid content percent	*1st grade*	*6th grade*	*Adults*
0.50	32	56	20
0.70	28	35	39
0.90	40	9	41

Table 4. Amount of difference in drink composition of acidity, sugar and pH, resulting in a significant taste difference.*

				Significance	
Series	*Acid*	*Sugar*	*pH*	*Test A*	*Test B*
I	.90 vs. 1.0	13	3.10	No	No
I	.85 vs. 1.0	13	3.22	Yes**	Yes
II	.90	13	3.22 vs. 3.33	No	No
II	.90	13	3.08 vs. 3.28	Yes	Yes
III	.85	13.0 vs. 14.0	3.20	No	No
III	.85	13.0 vs. 14.5	3.20	Yes	Yes
IV	.85 vs. 1.05	13	3.22 vs. 3.32	Yes	Yes
IV	.85 vs. 1.05	13	3.23 vs. 3.43	No	Yes
IV	.85 vs. 1.05	13	3.22 vs. 3.52	No	No
IV	.85 vs. 1.05	13	3.24 vs. 3.64	Yes	Yes

* Each liter of drink contained 400 ml grapefruit juice, 50 ml orange concentrate, 50 ml strawberry puree, 50 grams added sugar and distilled water to volume.

** "Yes" indicates appraisal difference at .05 level of statistical isgnificance.

the panel did not distinguish a difference in acidity of 0.1% (between 0.90 and 1.0% at pH 3.10) but did distinguish a difference of 0.15% (between 0.85 and 1.0% at pH 3.22). In Series II, where the acidity and Brix remained constant but a difference in pH was created by addition of the buffer, sodium citrate, the panel could not distinguish a difference of 0.1 pH but did distinguish a difference of 0.2 pH. In Series III, where sugar levels were raised by increments of 0.50%, a significant taste difference was noted between drinks of 13.0 and 14.5° Brix, but not between drinks of 13.0 and 14.0° Brix.

In Series IV, the sugar level (13°) and the pH (3.22) of the juice having the low acidity (0.85%) remained constant. An increase in acidity of 0.2% (to 1.05) was compensated for by raising the pH (by addition of sodium citrate). When the pH was raised by 0.3 units (3.22 to 3.52) the panel was unable to distinguish between the two juices of 0.85 and 1.05% acidity. Continued addition of the buffer to a pH of 3.64 resulted in again creating a distinguishable taste difference between the 0.85% acid juice and the juice having an acidity of 1.05%. The addition of the buffer to the higher acid drink made this drink, as far as the taste panel was concerned, less tart. In this connection, if sodium citrate, or other suitable buffer, is added to high acid grapefruit juice, the juice will taste sweeter.

Influence of color on acceptance by children:

As mentioned before, little can be done about the color of pure natural drinks. Color is recognized as one major factor in grading orange juice, and the addition of any color other than those naturally occurring in oranges, is prohibited. With blended drinks, especially citrus-berry or citrus-grape blends, a wide latitude of color selection is possible and consumer reaction to drink color becomes an important consideration. Color preference is often unrecognized by the subject and when a taster is asked why a colored drink is preferred over the identical drink without color, the answer will often be that the colored drink is sweeter, less acid, or has a better flavor. That color makes a great deal of difference to children was demonstrated by giving 145 first and second grade children their choice of a drink colored bright red and the same drink without added color. Of the 145 children participating, 120 expressed their preference for the colored drink.

Storage studies:

Figures 1 and 2 show the influence of storage time 7 and 14 months and storage temperatures (0, 40, 50, 68, RT° F.) on color and flavor of a 4-fold grapefruit-strawberry-orange concentrate. Samples in both plain and enameled tin cans, stored in the frozen condition, were judged very acceptable as to both flavor and color at the end of 14 months storage.

Samples stored at 40, 50 and 68° F. in plain tin cans were judged to have acceptable flavor and color after 7 months storage. Color of concentrate in enameled cans deteriorated during 68° F. storage. Color and flavor of samples stored at 40 and 50° F. in enameled cans were acceptable after 7 months storage.

All samples stored at room temperature (75-90° F.) were judged to have become unacceptable as to both flavor and color during the 7 months storage period.

It was the conclusion of the investigators that although these drinks were heat stabilized and did not spoil quickly when kept unfrozen, drink concentrates should be handled as is fresh frozen orange concentrate and kept frozen during storage and marketed from frozen food cabinets.

Acceptable formulations:

A very large number of different drinks, both synthetic and natural, are on the market. To have a possibility of competing successfully with what is now available, a new formulation must have wide appeal and must be produced cheaply. Although the formulations reported for Texas Punch (Lime and Griffiths, 1962) were considered good and also inexpensive, synthetic drinks such as Tang would appear to compete more favorably for consumer acceptance. Emphasis was therefore placed on formulating a "pure" or natural blend which could be produced inexpensively and would have a wider appeal than the usual canned grapefruit juice. Of the various ingredients considered, a combination of strawberry puree, lemon concentrate, grapefruit juice and sugar seemed to offer the most promise from the standpoint of acceptability, availability of ingredients, and cost. It was also found that if care was taken

to select grapefruit juice of mid or late season fruit, the bitterness, when the drink was diluted for use, was not sufficient to be objectionable and was largely masked by the berry flavor (Griffiths, et al., 1964). It was not considered necessary to debitter grapefruit juice as had been done for former formulations. The strawberry puree added a desirable pink color and the use of commercial 6-fold lemon concentrate made it possible to formulate a drink base which could be diluted for use with 3 volumes of water, or water and ice. The flavor of this product withstood heat stabilization or flash pasteurization and flavor and color was

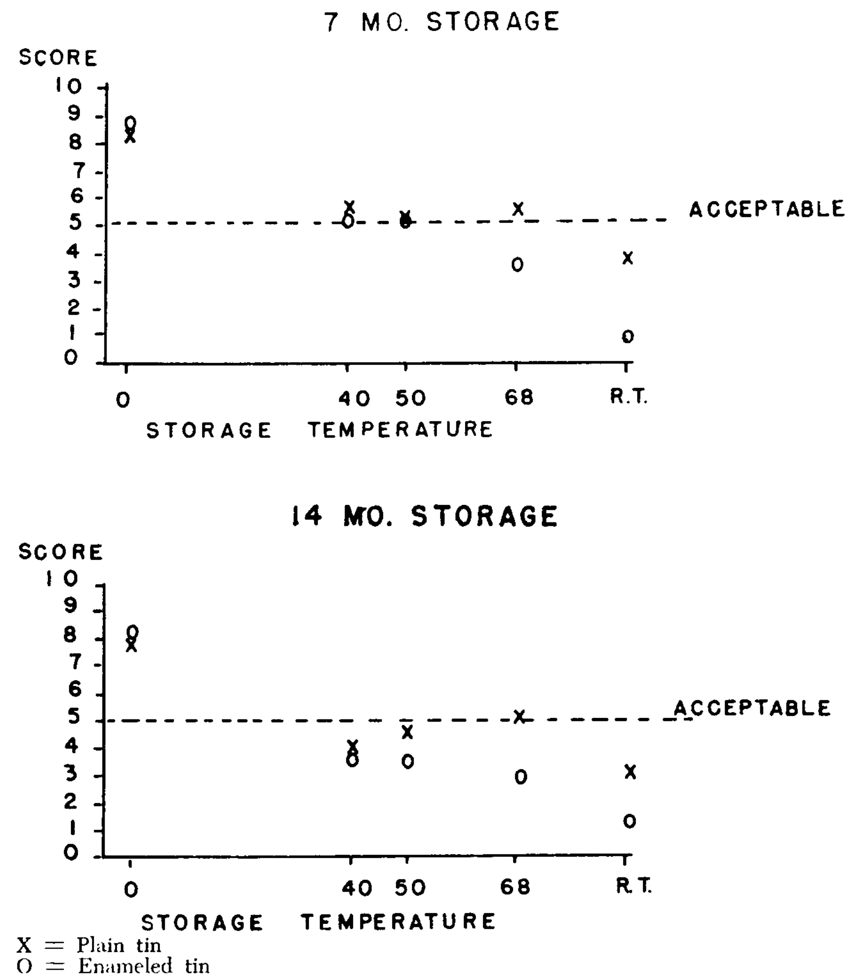
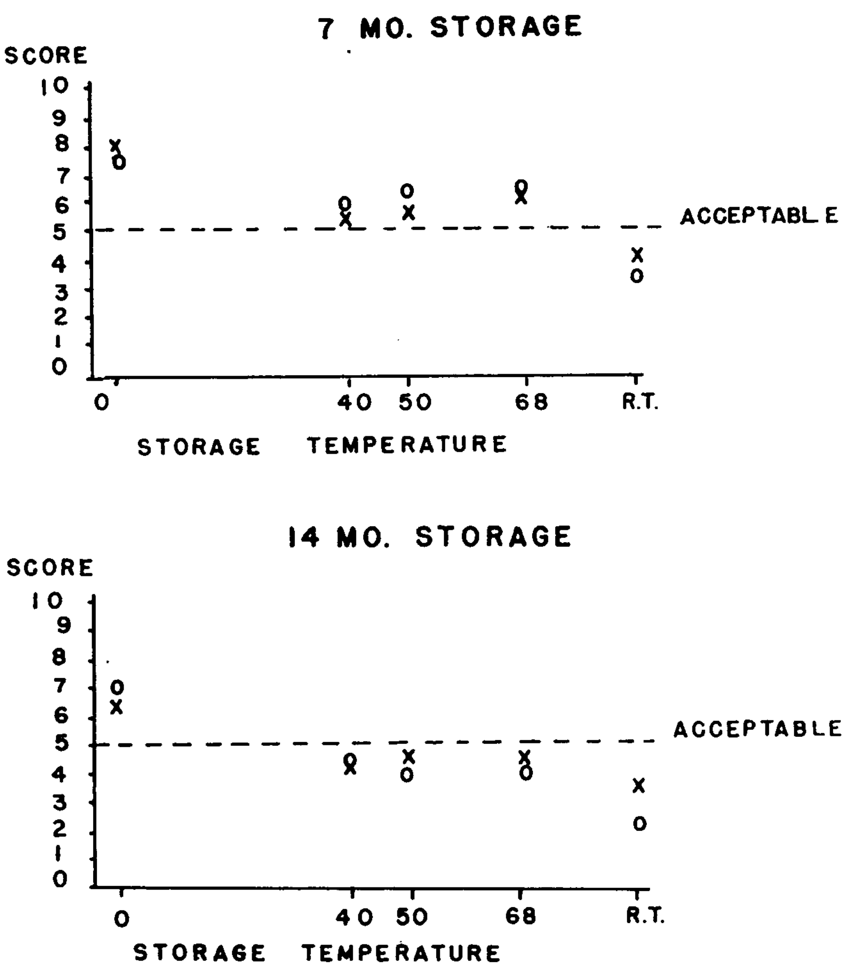


Figure 1. Effect of type of can, temperature and length of storage on color of grapefruit-strawberry-lemon concentrate drink.

retained by frozen storage for an indefinite period and at low temperatures, 40-60° F., for at least 7 months. The drink contained a significant amount of vitamin C (8.4 mgs per 100 ml) which could be brought up to 30 or 40 mgs per 100 ml by addition of the crystalline material, if marketing conditions made this desirable.

The results of the processing study and acceptance tests indicate that this product may have good commercial possibilities. Formal market



X = Plain tin
O = Enameled tin

Figure 2. Effect of type of can, temperature and length of storage on flavor of grapefruit-strawberry-lemon concentrate drink.

testing is needed to determine its potential for expanding the market for grap it.

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'Hudson' Grapefruit, a Seedy, Deep-Red-Fleshed Budsport of 'Foster Pink'[1]

R. A. Hensz[2]

ABSTRACT

'Hudson' is a seedy grapefruit with deeper red flesh color and redder peel than 'Redblush'. It was discovered as a mutation on a 'Foster Pink' tree in the mid-thirties by Mr. Charles E. Hudson, San Benito, Texas.

INTRODUCTION

Texas grapefruit plantings are predominantly 'Redblush', a seedless, red-fleshed variety whose color decreases in intensity from red in early fall to pink in late winter and spring (Purcell, 1959). A variety similar to 'Redblush' but having more red color throughout the season would be of economic importance.

In the mid 1930's Mr. Charles E. Hudson discovered several highly colored fruit on the lower limb of a 'Foster Pink' grapefruit tree in his orchard near San Benito, Texas. The tree had been frozen to just above the bud union a few years earlier. The fruit had red blushes on a red-tinted yellow peel. Throughout the growing season the flesh was deeper red than 'Redblush'. Mr. Hudson and his cousin, Mr. Charles E. Hudson, Jr., propagated a number of trees from the new sport. The fruit characters remained stable with no reversions to the 'Foster Pink'.

Description

Fruit color yellow with reddish tint and areas of distinct red blushes; surface smooth; shape oblate to globose; size large as 'Foster Pink'; mesocarp color reddish; flesh deep red, texture smooth; segments 10-14; juice abundant; quality good; seediness, 40 or more polyembryonic seeds; maturity October to May; peel color-break develops earlier than 'Redblush', fruiting precocious and heavy in clusters; tree small, possibly due to heavy crops beginning in early years.

Analysis by Purcell (1961) and Meredith (1966) in mid winter and early spring showed that the 'Hudson' fruit contains about 3 times as much lycopene (red pigment) as does 'Redblush'. Purcell also noted that in mid winter the juice had a Brix of 10.0% and the acid was 1.40%.

[1] Cooperative citrus research of Texas College of Arts & Industries and Texas Agricultural Experiment Station of Texas A & M University, Weslaco.
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Potential uses for the 'Hudson' grapefruit

The 'Hudson' is so seedy that there is little likelihood the fruit can be used in the fresh market. It does, however, have prospects for use in processing. The deep red flesh color is very attractive and processors have shown an interest in the fruit for frozen sections. The juice does not retain the red color.

To citrus breeders the variety is an important gene source for deep red flesh of good quality and of exceptional peel color. With these genetic characters available it may be possible to develop a seedless variety having flesh and peel qualities similar to 'Hudson'.

In 1959 the 'Hudson' grapefruit was included in a mutation-breeding program at the Texas A&I College Citrus Center (Hensz, 1960). Seeds and buds were subjected to the ionizing radiation of X-rays and thermal neutrons. The purpose was to induce mutations or budsports, one of which might have all the qualities of the 'Hudson' except the seediness. By 1965, 16 out of 750 progeny trees had borne fruit, all typical of the parent variety.

Seedling (nucellar) trees produced fruit that was as bright red as the old line. This is to be expected considering the performance of nucellar 'Foster Pink' trees (Cameron, et al., 1964).

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LETTER TO THE EDITOR

Dear Sir:

The "Hudson Foster Pink" is a new red grapefruit variety having excellent color characteristics. In late May, this variety was treated with boiling water to loosen the peel, peeled, and the endocarp was treated with a 1% lye solution to remove the albedo. The fruit was then sectionized and the sections frozen. This variety of fruit held up very well to the hot water and lye treatment, and did not undergo the normal softening or weeping that takes place in the Ruby Red variety. The sections were firm, maintaining very good color, and had a very pleasing appearance. This preliminary work indicates that the Hudson has excellent possibilities as a variety for sectionizing and could therefore be used in chilled salad mixes or prepared as a frozen product. Further work is planned in the next season on processing uses of this variety.

Very truly yours,

Filmore I. Meredith, Research Chemist
Bruce J. Lime, Research Chemist
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Evaluation of 'Fairchild,' 'Fortune,' and Other Tangerine Hybrids in Texas

E. O. OLSON, N. P. MAXWELL, BAILEY SLEETH, and BRUCE LIME[1]

ABSTRACT

Three years of fruiting have shown that 'Fairchild' and 'Fortune' tangerine hybrids are well-adapted to Texas conditions. They appear superior to other tangerines and have been released for commercial propagation by Texas nurserymen.

INTRODUCTION

Since 1959, the U. S. Department of Agriculture released eight new tangerine hybrids for commercial propagation: 'Robinson,' 'Lee,' 'Osceola,' 'Page,' 'Nova' in Florida; and 'Fairchild,' 'Fremont,' and 'Fortune' in California. These have been grown at the Texas Agricultural Experiment Station field locations to determine their adaptability to Texas growing conditions. Texas Agricultural Experiment Station regulations provide that a new variety must fruit for at least three seasons, be free of bud-transmitted diseases, and be adapted to Texas soils and climate before commercial release. A variety must also be superior to those already in commercial use. Fortune and Fairchild, two highly promising varieties, have been released for propagation by Texas nurserymen. Commercial plantings should be on a trial basis.

When grown at Weslaco or near Monte Alto, Texas, fruits of Lee, Osceola, Page, Nova and Fremont (Table 1) were consistently small or severely sunburned. Nursery and orchard trees of a sixth variety, Robinson, were unusually sensitive to a fungus-caused twig dieback. The limitations of these six recent releases are serious enough for the USDA to withhold recommendations for release in Texas for the present. An earlier USDA release, 'Orlando,' has been successful in Texas.

The Fairchild and Fortune tangerine varieties, originally selected under California desert conditions by J. R. Furr, seemed well adapted to Texas conditions. When ripe the fruit is highly colored and of excellent quality. Trees of both varieties have dense, spreading tops that form a leafy canopy which protects the fruit from sunburn and frost. Trees of Fairchild and Fortune have fruited for 3 or more years at Rio

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Table 1. An evaluation of named tangerine hybrids fruiting in 1966 near Monte Alto, Texas.

Variety	*Maturity season*	*Origin*	*Evaluation and limitations of variety in South Texas*
Fairchild	Nov.-Dec.	USDA, Calif.	Most promising early-season selection
Orlando	Dec.-Jan.	USDA, Fla.	Standard mid season variety
Fortune	Feb.-Mar.	USDA, Calif.	Most promising late variety
Celmentine	Dec.	Algeria	Small fruit, some granulation
Changsha	Oct.	China	Insipid fruit
Dancy	Feb.	Florida	Puffy fruit
False Hybrid Satsuma	Oct.	Japan	Rough appearance, bland flavor
Fremont[a]	Jan.	USDA, Calif.	Small fruit
Kara	Mar.	Calif. Exp. Sta.	Rough appearance
Kinnow	Feb.	Calif. Exp. Sta.	Alternate bearer
Lee[a]	Nov.	USDA, Fla.	Sunburned fruit
Murcott	Feb.-Mar.	Florida	Sunburned fruit
Nova[a]	Dec.	USDA, Fla.	Sunburned fruit
Osceola[a]	Nov.	USDA, Fla.	Small fruit
Page[a]	Nov.	USDA, Fla.	Small fruit, low yields
Pearl	Nov.	Calif. Exp. Sta.	Yellowish rind, pulp
Pong Koa	Feb.	Asia	Puffy fruit, similar to Ponkan
Robinson[a]	Oct.	USDA, Fla.	Susceptible to fungus-caused twig dieback
Thornton[a]	Dec.	USDA, Fla.	Yellowish peel, pulp

[a] Not released for commercial propagation in Texas.

Farms, Inc., Monte Alto, Texas, and at the Lower Rio Grande Valley Research and Extension Center at Weslaco, Texas. The trees which were frozen in January 1962 have recovered. Fortune and Fairchild require pollination by other varieties. Since yield data are lacking, trial plantings should be on a limited scale, pending wider evaluations. Indexing tests have shown that the budwood source trees are free of the viruses causing psorosis, tristeza, xyloporosis and exocortis.

Comparisons of fruit characteristics of Fairchild and Fortune with other tangerines in 1965-1966 are presented in Tables 2, 3, 4, and 5. For analysis, 10 to 15 fruits of each variety were taken to the laboratory. The fruit was arranged on a long table, so that the exterior color and appearance of each could be compared. After the exterior color was recorded, the fruit was halved and the interior color and size of the center cavity were noted. The flavor notations were obtained from 3 or 5 people who tasted sections of the halves and described the flavor. The remaining fruit of each variety were hand-reamed with a burr-type juice extractor for acid and Brix determinations. The acid content was determined by titration with standard sodium hydroxide and reported as anhydrous citric acid. The Brix was determined by direct reading with a refractometer.

FAIRCHILD, TR 31

Fairchild (tested as C48-14-39) originated from a cross of Clementine tangerine X Orlando tangelo made by J. R. Furr at Indio, California. The ripening season in the Lower Rio Grande Valley of Texas is November to December; the variety matures before either parent. The fruit is of medium size, about 2½ inches in diameter, with an easily removed orange-colored peel. The tree is vigorous and productive. In earliness, fruit and flesh color, and flavor, the Fairchild seems superior to those commercial tangerines which are available for November to December harvest (Tables 2 and 3).

Table 2. Fruit characteristics of Fairchild and certain other varieties on November 3, 1965.

Variety	*Fruit size (inches)*	*Peel color*	*Interior color*	*Fruit flavor*	*Center cavity of fruit*
Fairchild	2½	bright orange	bright orange	very good	small
Changsha	2	bright orange	bright, deep orange	insipid	medium
Clementine	2	green	pale orange	insipid	large
Orlando	3-4	yellow green	yellow orange	not quite ripe	large
Page[a]	1½-2	yellow orange	bright, deep orange	very good	very small
Pearl	3	yellow green	pale yellow	sweet insipid	small
F6-8-16[ab]	2½	yellow orange	bright, deep orange	not quite ripe	large

[a] Not released for commercial propagation in Texas.
[b] Clementine x Orlando hybrid, and a sister hybrid of Robinson, Lee, Osceola, and Fairchild.

Table 3. Brix and acid of fruit of Fairchild and other varieties on indicated dates in 1965.

Variety	*Oct. 19* Brix	Acid	*Nov. 3* Brix	Acid	*Nov. 29* Brix	Acid	*Dec. 23* Brix	Acid
Fairchild	13.0	1.65	13.4	1.62	14.2	1.22	16.2	1.12
Changsha	10.8	0.61	11.8	0.52	......	......	......	......
Clementine	10.0	0.71	11.2	0.78	11.2	0.67	12.2	0.65
Orlando	10.6	1.33	11.0	1.15	11.6	0.85	12.6	0.84
Page[a]	......	......	11.2	0.83	12.4	0.85	13.6	0.76
Pearl	11.8	0.83	12.2	0.90	12.4	0.91	14.0	1.02
F6-8-16[ab]	11.4	1.33	10.6	1.23	12.0	0.97	......	......

[a] Not released for commercial propagation in Texas.
[b] Clementine x Orlando hybrid, and a sister hybrid of Robinson, Lee, Osceola, from Florida.

FORTUNE, TR 32

Fortune (tested as C-48-9-6) originated from a cross of Clementine tangerine X Dancy tangerine made by J. R. Furr at Indio, California. The fruit is medium to large in size, 2½ to 3 inches in diameter, with a close fitting peel that can be readily removed. It ripens in late February and March. The flavor is sprightly and pleasing when ripe, but tart before the fruit matures. The flesh is orange-colored, juicy, and tender. The tree is vigorous and productive. Fortune fruit is less subject to granulation than 'Murcott,' a Florida variety which matures at the same time. Fortune matures after 'Dancy' fruits are gone.

On March 8, 1965, Texas-grown Fortune fruits had a Brix of 15.6, acid of 1.73%, yellowish-orange juice, orange-colored peel, diameter about 3 inches, medium-sized central cavity, and numerous seeds. For additional 1966 data see Tables 4 and 5. Fortune seems superior to any late-maturing commercial tangerine or tangelo available in Texas (Tables 4 and 5).

Table 4. Fruit characteristics of Orlando, Fortune, and certain other varieties on January 20, 1966.

Variety	*Fruit size (inches)*	*Peel color*	*Interior color*	*Fruit flavor*	*Central cavity*	*Rind thickness (mm)*
Orlando	3	yellow orange	yellow orange	good	large	3.0
Fortune	3	orange	bright orange	tart	small	3.0
Dancy	2	reddish orange	bright orange	tart	large	2.5
Fremont[a]	2	reddish orange	bright orange	rich, sweet	small	2.5
Kara	3	green, yellow	bright orange	tart	small	4.0
Kinnow	2	orange	bright orange	rich, sweet	small	4.0
Pong Koa	3	orange	bright orange	rich, sweet	large	3.0
Thornton	3	yellow orange	yellowish	watery	large	4.0
C48-18-8[ab]	2	orange	deep orange	rich, sweet	medium	2.0
C52-83-16[ac]	2	orange	bright orange	rich, sweet	small	2.5

[a] Not released for commercial propagation.
[b] Temple "orange" x Honey mandarin hybrid from California.
[c] King "orange" x Orlando tangelo hybrid from California.

Table 5. Brix and acid of fruit of Orlando, Fortune and certain other varieties in late winter and spring of 1966.

	Jan. 20		*Feb. 4*		*Feb. 28*		*Apr. 6*	
Variety	*Brix*	*Acid*	*Brix*	*Acid*	*Brix*	*Acid*	*Brix*	*Acid*
Orlando	12.0	0.77	13.0	0.78	13.2	0.80	......	......
Fortune	13.4	1.48	11.4	1.40	12.6	1.31	13.6	1.15
Dancy	13.2	1.30	12.6	1.28	14.2	1.37	14.8	1.06
Fremont[a]	15.2	0.81	16.2	0.84	......	......	......	......
Kara	11.4	1.20	13.8	1.29	13.6	1.21	14.6	1.60
Kinnow	12.2	0.72	12.4	0.75	14.4	0.75	......	......
Pong Koa	......	......	13.4	0.89	15.0	0.92	......	......
Thornton	......	......	12.8	0.75	12.6	0.74	......	......
C48-18-8[ab]	15.2	0.97	15.6	0.96	16.4	0.90	17.6	1.03
C52-83-16[ac]	11.4	1.02	13.6	1.05	16.0	1.15	......	......

[a] Not released for commercial propagation in Texas.
[b] Temple 'orange" x Honey mandarin hybrid from California.
[c] King "orange" x Orlando tangelo hybrid from California.

A Meyer Lemon Rootstock Trial: Scion-Rooting, Tree Growth, Yield, and Tree Survival After a Severe Freeze

E. O. OLSON and ART SHULL[1]

ABSTRACT

'Meyer' lemon yields between 1957 and 1965 were obtained from tristeza-free layers and trees budded on 8 rootstocks.

Budded trees on 'Rangpur' mandarin lime, 'Colombian' sweet lime, and rough lemon rootstock made the best start. Trees on 'Carrizo' citrange rootstock showed a stain at the bud union and stunting attributed to "tatter leaf" virus.

Yields in 1964 and 1965 were inversely proportional to cold damage in 1962. Trees on 'Cleopatra' mandarin rootstock showed least damage from the 1962 freeze and had best yields in 1964 and 1965.

Trees with buried bud unions scion-rooted, and none died from the 1962 freeze. Similar trees with above-ground bud unions with cold-sensitive rootstocks were sometimes killed. Most trees with buried bud unions had a 2-story root system, no rootstock sprouts to be pruned out, and yielded as well or better than similar trees with bud unions above ground.

Trees from rooted layers, set out as smaller plants, had yields as good as those of budded trees on sour orange rootstock. In a commercial planting, more than 98% of the rooted-layer trees survived the 1962 freeze.

INTRODUCTION

'Meyer' lemon [*Citrus limon* x *C. sinensis*? (Swingle, 1946)] is more cold hardy than 'Eureka' or 'Lisbon' lemons (McKee, 1926; Bingham, 1933). In South Texas and Florida it is grown for fresh fruit sales and limited processing. It also may be used as a backyard variety in regions too cold for Eureka or Lisbon lemons.

Periodic freezes are the major hazard in growing Meyer lemon trees in South Texas. The cultural system and propagation system that provides best tree survival and fruit yields after periodic freezes is the best one for this area.

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McKee (1926) reviewed growers' erratic experience with rootstocks for Meyer lemon in different areas and recommended growing it on its own roots. In the 1930's several planting systems evolved in South Texas. In some cases, trees on sour orange rootstock were planted deep with the bud union buried so that roots would form above the bud union from the Meyer lemon top (Bingham, 1933). In other cases, Meyer lemon trees were propagated by rooted cuttings or layered branches. Trees grown from rooted cuttings were good fruit producers, but those on sour orange rootstock were not satisfactory (Friend and Wood, 1941). Later, a local nurseryman found that the Ricketts selection of Meyer lemon grew vigorously on sour orange rootstock (Baker, 1942). Subsequently, trees of the Ricketts selection were shown to be free of tristeza virus, which stunts trees grown on sour orange rootstock (Olson and Sleeth, 1954).

In the present experiment two items were investigated: (1) Effect of rootstock on tree growth and fruit yield, and (2) Effect of planting with bud union above ground or buried, in comparison to rooted layers, on freeze survival of budded trees.

PROCEDURES

The trees in this experiment were propagated from a single Ricketts Meyer lemon tree in a grove near LaSara, Texas. The budwood-source tree was shown to be free of tristeza, exocortis, xyloporosis and psorosis (Olson et al., 1958). However, tests in California showed that it carried "tatter leaf" virus (Wallace and Drake, 1962).

The technique used to produce layered trees was similar to that described by Webber (1948).

Nine-month-old rooted layers, and one-year-old trees budded on several different rootstocks were set in the field in April 1955 at Rio Farms, Inc., Monte Alto in replicated blocks. The rootstocks used are listed in Tables 1 and 2. In each replication a 3-tree group on each rootstock was set in normal manner with bud union 4 to 6 inches above ground. In many but not all replications, an adjacent 3-tree group on the same rootstock was set with the bud union buried 4 to 6 inches underground. The number of replications varied from one to four.

The trees were spaced 25 feet by 15 feet and given usual grove care, including clean cultivation and irrigation.

Yields were recorded as 70-pound boxes of fruit. Trunks of trees planted with bud union above ground (hereafter referred to as normal) were calipered 4 inches above the bud union in 1958 and 1962; those with buried bud unions were not measured. The influence of rootstocks on fruit size, volume of juice, and sugar-acid ratio has been reported (Woodruff and Olson, 1960).

Table 1. Freeze injury to Meyer lemon on various rootstocks near Monte Alto, Texas.

Rootstock varieties with bud unions above ground	Freeze injury[1] to wood (inches)	Percentage dead trees at indicated times after 1962 freeze	
		4 months[1]	4 years
Cleopatra mandarin	2.7	0	0
Rangpur mandarin lime	3.8	80	25[2]
Sunshine tangelo	2.8	20	0[2]
Sour orange	3.5	60	50[2]
Sunki mandarin	3.0	20	0[2]
Columbian sweet lime	4.0	90	33[2]

[1] Quoted for convenience from published reports of Young and Olson (1963).
[2] Some trees considered dead 4 months after the freeze subsequently produced a new top from dormant buds.

Table 2. Meyer lemon tree survival, scion rooting, tree growth and yield before and after a severe freeze in 1962.

Rootstock or rooted layer	Bud union	No. trees in trial before & after 1962 freeze		No. scion-rooted trees	% scion roots in scion-rooted trees (visual estimates)	Trunk diameter (in.) D" above bud union		Annual yield per tree in boxes for indicated years	
		1961	1966	1966		1958	1962	1957-61	1964-65
Cleopatra mandarin	normal	12	12	2	7	3.5	6.4	1.0	1.5
	buried	12	12	11	32	—	—	1.2	2.5
Sour orange	normal	9	7	1	20	3.4	6.2	.8	.9
	buried	9	9	8	39	—	—	1.1	1.5
Rangpur mandarin lime	normal	6	6	5	14	4.8	6.9	2.0	1.0
	buried	6	6	5	63	—	—	2.0	1.8
Columbian sweet lime	normal	9	5	2	17	4.1	5.9	1.7	.4
	buried	9	9	9	36	—	—	1.6	1.0
Sunshine tangelo	normal	9	9	1	20	3.9	6.4	1.4	1.7
Sunki mandarin	normal	12	12	1	10	3.4	5.8	1.2	1.3
Rough lemon	normal	3	3	2	62	4.4	6.3	2.1	.9
Carrizo citrange	normal	2	2	2	98	1.8	2.6	.1	.7
Rooted layer	normal	6	6	6	—	—	—	1.2	1.6

The amount of scion-rooting[2] was estimated visually and recorded after the trees were pulled and the roots exposed in February 1966.

RESULTS AND DISCUSSION

Effect of Rootstock on Tree Growth and Yield

Meyer lemon trees on Rangpur mandarin lime, Columbian sweet lime, and rough lemon rootstocks made the best start, as shown by trunk measurements in 1958 and average yields from 1957 to 1961 (Table 2).

In 1957 trees on Carrizo citrange rootstock showed a light brown stain in the bark at the bud union. The stain extended several inches down onto the rootstock. By 1965, the trees on Carrizo citrange rootstock had scion-rooted, apparently because soil had covered the bud union during cultural operations. In February 1966, an estimated 98% of the root system had developed from above the bud union; the Carrizo citrange roots apparently made little growth since planting.

In California "tatter leaf" virus, in combination with tristeza virus, has caused a bud-union crease, chlorosis, slight stunting and general decline of satsuma mandarin trees on 'Troyer' citrange rootstocks (Calavan et al., 1963). Since "tatter leaf" virus is generally present in Meyer lemon selections, including the tristeza-free ones from Texas (Wallace and Drake, 1962), bud-union stain and stunting of Meyer lemon tops on Carrizo citrange rootstock is probably caused by "tatter leaf" virus infection. Troyer citrange and Carrizo citrange are considered similar, if not identical, varieties.

During the 1962 freeze, the minimum temperature at Monte Alto near this field planting was 12°F. (Young and Olson, 1963). Immediately after the 1962 freeze, it was noted that damage was more severe to Meyer lemon tops on some rootstocks than others (Young and Olson, 1963). Trees on Cleopatra mandarin rootstock showed the least damage and those on sweet lime, sour orange and Rangpur mandarin lime were more severely damaged (Table 1). The yields in 1964-65 also reflect cold damage in 1962.

Highest fruit yields before the freeze (1957-1961) occurred on trees on Rangpur mandarin lime, sweet lime, and rough lemon rootstock. Since the freeze, the best yield in the two crop years (1964-65) came from trees on Cleopatra mandarin rootstock with a buried bud union. Trees from rooted layers showed uniform recovery in growth, yield, and survival from the severe freeze of 1962.

[2] Chandler (1950) (page 100) defined scion as the bud or piece of stem attached to the rootstock, also the part that grows from that scion, the part above the bud union, throughout the life of the tree. In this paper scion is used in the latter meaning.

Effect of Buried Bud Unions on Survival After the 1962 Freeze

The test plantings described in Table 1 include only trees with normal bud unions. In Table 2, comparisons are made between equal numbers of similar scion-rootstock combinations planted with normal or buried bud unions.

The tree damage from the 1962 freeze was greater when the bud union was above ground; none died when the bud union was buried (Table 2). Trees with buried bud unions were naturally protected from freeze damage below the soil line by the latent heat in the soil. After the freeze, sprouts developed from the above-ground portions of some rootstocks, but not when the bud union was buried.

The deeper-planted trees also had more scion-rooting from the Meyer lemon trunks of trees on 4 rootstocks: Cleopatra mandarin, sour orange, Rangpur mandarin lime, and Columbian sweet lime. In February 1966, 33 of the 36 trees with buried bud unions had scion-rooted and had a 2-story root system. Such trees had Meyer lemon roots above the bud union and, except for Carrizo citrange, had vigorous roots of the original rootstock below the Meyer roots. Where soil banks for winter protection were not removed, or where cultivation covered bud unions, scion-rooting sometimes occurred on trees planted with normal bud unions. Scion-rooting also accounted for the survival of some of the badly injured trees on rough lemon rootstock and for survival of the trees propagated on Carrizo citrange rootstock.

Trees developed from rooted layers had average annual yields somewhat lower than those obtained from trees with buried bud unions. This may be because they had a smaller top and a younger and smaller root system at the beginning of the experiment. The rooted layers were 9 months old when set in the field; the grafted trees had a 2½-year-old root system and a 1-year-old top.

After the 1962 freeze, trees from rooted layers developed a new top and produced a crop 2 years after the top had been frozen to the ground. With such trees, post-freeze pruning consisted only of removal of freeze-injured wood. There were no rootstock sprouts to remove. The trees in our test behaved like those in commercial plantings. In one commercial planting at Rio Farms, Inc., trees grown from rooted layers set out in 1955 were frozen to the ground during the 1962 freeze. Dead wood in these trees was pruned out and new tops formed from new sprouts which grew from the roots and crowns. These trees have fruited since 1964. Counts from an aerial photo made prior to the freeze showed that this planting originally consisted of 1490 trees. In February 1965, more than 98% of these trees had survived; some of the 2% loss was due to causes other than freeze damage.

Grower's Choice of Propagation Systems for Meyer Lemon

The best propagation system for Meyer lemons in South Texas is the one that provides best tree survival and fruit yields after periodic freezes. On the basis of our tests, a grower has 4 choices. First, the

grower can propagate tristeza-free trees on sour orange rootstock, plant with bud union above ground, and know that the rootstock is well adapted to Texas soil and water conditions. These trees are vulnerable to severe freezes. Second, the grower can propagate trees on Cleopatra mandarin rootstock, plant them with the bud union above ground and, based on experience in 1962, have a more cold hardy tree. But since freezes are erratic it is not necessarily hardy enough to protect the tree from freezing back to the bud union in another freeze. Furthermore, trees on Cleopatra mandarin rootstock are commonly chlorotic on calcareous soils. Third, the grower can set out trees on Cleopatra mandarin or sour orange rootstock, plant them with bud union buried, and have some assurance that the latent heat of the soil will protect the scion from freeze damage below the soil line. Deep planting is difficult in shallow soils. Many growers distrust this method, because they have been taught to plant sweet orange and grapefruit trees with the bud union above ground, to avoid *Phytophthora* fungus-caused foot rot. This problem, if present, was not detected in the present trials. Such deep-planted trees eventually scion-root and become similar to trees on their own roots. Fourth, the grower can set out trees on their own roots, propagated by layers or cuttings, and know that the latent heat of the soil protects the crown and roots. Such trees can be frozen to the ground and recover in 2 years. This system seems to offer greatest chance of tree survival after a severe freeze.

Rooted layers may require more care the first year than budded trees on sour orange or Cleopatra mandarin rootstock. Even if these trees from rooted layers yield less than trees on fast-growing rootstocks, the yield loss is a small price to pay for increased security in freeze survival.

No matter what system a grower chooses, he should not propagate from trees carrying tristeza virus.

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Relative Cold Tolerance of Progenies of Some Citrus Crosses

J. R. Furr, Ralph T. Brown, and E. O. Olson[1]

ABSTRACT

Crosses involving citrus varieties that vary widely in their cold tolerance were made in 1964. Plantings were damaged by sub-freezing temperatures in both California (25°F.) and Louisiana (18°F.) in 1966.

In California seedlings of Clementine X Tanka were the most cold tolerant and the progeny of crosses involving grapefruit varieties had the least cold resistance. In Louisiana progeny of Changsha were highly cold tolerant; Wilking X Owari, Wilking X (Clementine X Owari) and Clementine X Wilking produced relatively high percentages of cold-tolerant seedlings. Many of the crosses were comparatively low in cold resistance.

Frost damage to citrus in recent years in most citrus-growing regions of this country has stimulated interest in breeding citrus for cold tolerance. Cooper (1962) stated "Scion varieties with greater cold hardiness are especially needed to stabilize the citrus industry in Texas". In the small citrus-growing region of Louisiana, varieties with greater cold tolerance are needed to maintain the very existence of the industry.

Crosses involving parental combinations varying widely in cold tolerance were made in 1964 by Furr and Olson at the U. S. Date and Citrus Station, Indio, California.

Seed resulting from some of these crosses were planted at Indio; others, particularly those involving the most cold-tolerant parents, were planted at the Plaquemines Parish Experiment Station, Port Sulphur, Louisiana, and at Rio Farms, Monte Alto, Texas. After one growing season in the field, the seedlings in Louisiana and California were damaged by cold. On January 2, 1966, the temperature at Indio, about 4 miles from the plantings, reached a minimum of 25°F. and was below 30° for 5 hours. On January 3, the minimum was 27°F. and the temperature was below 30° for 4 hours. Minimum temperatures at the planting site probably were several degrees lower each night. The plants at the Plaquemines Station were exposed to a minimum of 18°F. on January 30, 1966.

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This paper reports the relative cold tolerance of seedling families from the different crosses represented in the Louisiana and California plantings.

RESULTS AND DISCUSSION

At Indio, cold injury was evaluated on January 14, when dead leaf tissue was clearly distinguishable from living tissue. Stem injury varied from killing of the tips to apparent death of the stem to the ground line. Because of the careful examination required, evaluation of stem injury was slow, but plants could be scored rapidly for percentage of frost-injured leaves.

Consequently, leaf injury alone was used as a measure of relative cold injury. The 19 families of seedlings grown at Indio are listed in approximate order of cold tolerance in Table 1. Only the percentages of plants with little injury (0-20% of the leaved damaged) and those with severe injury (90-100%) are listed in Table 1; these two classes best show the relative tolerance of a family. The population of hybrid

Table 1. Cold tolerance of families of hybrid seedlings at Iindio, California, as indicated by the proportions of plants with slight (0-20%) or severe (90-100%) leaf injury.

Parents[1]	Plants with injured leaves 0-20%	Plants with injured leaves 90-100%	Total population
	(%)	(%)	(No.)
'Clementine' X 'Tankan'	48.0	8.0	152
'Clementine' X 'Kinnow'	33.0	10.0	1405
'Clementine' X ('Clementine' X 'Ruby')	31.0	15.0	536
'Pearl' X 'Duncan'	30.0	31.0	83
'Clementine' X 'Murcott'	26.0	9.0	253
('Clementine' X 'Wilking') X 'Ruby'	26.0	24.0	215
'Fortune' X 'Fremont'	19.0	22.0	99
'Clementine' X 'Wilking'	14.0	20.0	922
('Clementine' X 'Owari') X 'Kinnow'	13.0	14.0	331
('Clementine' X 'Dancy') X ('Clementine' X 'Ruby')	13.0	9.0	67
'Clementine' X 'Ruby'	8.0	43.0	104
'Clementine' X 'Mediterranean Sweet'	6.0	18.0	141
'Pearl' X Red Mexican	6.0	57.0	114
Red shaddock X 'Redblush'	2.0	73.0	206
'Meyer' X self	1.4	55.0	557
Red shaddock X Red Mexican	0.6	71.0	497
Red shaddock X 'Pearl'	0.4	87.0	282
('Umatilla' X 'Honey') X 'Ruby'	0	64.0	89
'Pearl' X 'Marsh'	0	25.0	12

[1] Varieties are tangerines except 'Ruby' and 'Mediterranean' sweet oranges; 'Pearl' tangelo; 'Redblush,' 'Marsh' and Red Mexican grapefruit; and Red shaddock.

seedlings representing a cross was large enough, in most instances, to give a fairly reliable estimate of relative cold tolerance, there being over 100 seedlings in all but 5 families. Seedlings of Clementine X Tankan were the most cold tolerant and the progeny of crosses involving Red shaddock Pearl tangelo and Red Mexican, Redblush, and Marsh grapefruits had little cold tolerance. Though Umatilla and Honey are hardy, the progeny of a complex hybrid cross (Umatilla X Honey) X Ruby blood orange were very tender. The selfed Meyer lemon seedlings that were hardy, although a small percentage of the total, seem promising. They were mostly vigorous ones, apparently without depression of vigor from inbreeding.

At Port Sulphur the families of hybrid seedlings were scored for both leaf and stem injury, and each family was compared with Owari seedlings of the same age as an index of frost injury. The crosses are listed in approximate order of cold tolerance in Table 2.

All progeny of Changsha were highly cold tolerant; Wilking X Owari produced a high percentage of cold-tolerant seedlings; Wilking X (Clementine X Owari) and Clementine X Wilking produced relatively high percentages of cold-tolerant seedlings. Of the 13 crosses, the poorest were those of Clementine X Page, (Clementine X Owari) X Kinnow and (Clementine X Silverhill) X Kinnow.

These results indicate that of the various parents used in the crosses

Table 2. Cold tolerance of families of hybrid seedlings at Port Sulphur, Louisiana, as indicated by the proportion not injured or killed and by the injury relative to that of 'Owari' seedlings.

Parents[1]	Plants with: Less injury than 'Owari'	No injury	All of top killed	Total population
	(%)	(%)	(%)	(No.)
'Wilking' X 'Changsha'	70	12	3	106
'Fortune' X 'Changsha'	63	12	15	162
'Wilking' X 'Owari'	45	14	19	42
'Wilking' X ('Clementine' X 'Owari')	44	4	24	68
'Clementine' X 'Changsha'	38	3	33	178
'Clementine' X 'Wilking'	34	9	30	128
('Umatilla' X 'Honey') X 'Wilking'	26	6	35	251
'Clementine' X ('Clementine' X 'Silverhill')	25	3	22	60
'Umatilla' X 'Kinnow'	10	2	55	266
'Clementine' X 'Murcott'	8	6	82	47
('Clementine' X 'Silverhill') X 'Kinnow'	5	0	66	131
('Clementine' X 'Owari') X 'Kinnow'	1	0	61	94
'Clementine' X 'Page'	0	0	100	28

[1] All tangerine types except Umatilla tangor.

listed in Tables 1 and 2 Changsha transmitted the highest degree of cold tolerance to its progeny. Wilking seemed superior to Owari as a source of cold tolerance. Mortensen (1954) reported that Changsha was uninjured in a freeze in which a minimum of 19°F. was reached, and Young (1963) reported only 50% injury of the terminals of Changsha seedlings 9-12 months old at Weslaco in the freeze of January 1962, when a minimum of 16°F. occurred. Changsha shows similarities in both vegetative and fruit characteristics to the satsuma group of mandarin and probably should be classed as a satsuma. Its fruit is insipid, but the tree is vigorous; and since it seems to be one of the best sources of cold tolerance in the genus *Citrus*, it may prove to be useful for incorporating cold tolerance not only in tangerines but in other species as well. Because Wilking produces only zygotic embryos, has excellent fruit quality and apparently transmits cold tolerance to its progeny, it also should be a very useful parent in breeding cold-hardy varieties of citrus.

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VEGETABLE SECTION

Texas Winter Carrots: Forecast Prices and Expected Crop Values[1]

CARL E. SHAFER[2]

ABSTRACT

The total crop value for South Texas winter carrots changed from year-to-year on the average by 46 percent during the 1954-1964 period. Equations developed for forecasting Texas "in field" prices and Texas f.o.b. prices explained over 75 percent of the variation in these prices; the explanatory variables were winter carrot production in both Texas and California and consumer income. The response of Texas' price to changes in both Texas production and California production was such that total crop value generally fell below average when production in Texas and/or California was above average.

The variable and, frequently, low price and low crop value situations experienced by South Texas growers were due in part to overproduction from excess acreages planted and/or high yields. Price forecasting equations were used to estimate the total crop values "expected" assuming (1) that growers followed the planted acreages recommended by the U.S.D.A. and (2) actual yields. "Expected" crop values were less variable over the 1955-1964 period and average 13 percent higher than actual crop values.

Net crop returns (revenue less costs) would probably have been significantly greater during the 1955-1964 period if growers had followed the recommended acreage issued by the U.S.D.A.; "expected" crop values would generally have exceeded the actual crop values and production and marketing costs would have been reduced with the smaller acreages.

INTRODUCTION

Winter carrots, which are produced almost exclusively in South Texas and California, constituted 35 per cent of the total U. S. annual carrot production during 1962-1964[3]. Texas generally supplies about 70

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1 This paper is based on a section of reference (2). A copy of this study may be obtained from the Department of Agricultural Economics and Sociology, Texas A&M University, College Station, Texas.

2 Assistant Professor of Agricultural Economics, Texas A&M University and Texas Agricutural Experiment Station, College Station, Texas.

3 Winter carrot season is defined as January, February and March but Texas winter carrots are usually shipped in volume well into May and sometimes June.

percent of the winter production with California providing the remainder. Because of the dominant position of Texas carrots in the winter market, the production and marketing decisions of growers and shippers in South Texas can affect prices and crop values significantly.

The total value of Texas winter carrot crops has varied considerably; e.g., dropping by 41 percent between 1958 and 1959 and increasing by 138 percent between 1960 and 1961. The year-to-year variation in crop values averaged 46 percent over the 1955-1964 period. The unstable pattern of returns to the resources used in carrot production and, frequently, low returns relative to the total costs of production are two of the economic problems associated with the production and marketing of Texas winter carrots during recent years.

Given the variable annual winter carrot crop values situation mentioned above, this paper is concerned with: (a) price forecasting equations for Texas winter carrots and (b) a comparison of actual crop values with crop values which might have been expected had winter carrot growers followed U.S.D.A. planted acreage recommendations.

PRICE FORECASTING EQUATIONS[4]

The equations developed to forecast Texas prices (both "in field" and f.o.b. prices) include total Texas winter carrot production, total California winter carrot production, and annual disposable personal income as independent variables. Over 75 percent of the variation in Texas prices was "explained" by changes in these three variables. The nearness of the estimated prices provided by the equations to the actual prices is shown in Figure 1. For example, the 1965 forecast f.o.b. price, $3.04 per hundredweight, was three percent below the actual reported price of $3.13 per hundredweight.

It was hypothesized that larger-than-average crops would bring smaller-than-average crop values; i.e., a crop which is ten percent larger than average can be sold only at a price of more than ten percent below average, thus the large crop has a smaller total value than does the average or smaller-than-average crop. Economists would say that the above situation is one of "inelastic" demand.

The price equations supported the hypothesis in that larger-than-average crops in Texas were associated with below average prices such that their total crop values were also below average.

Texas prices and California prices moved together closely, reflecting the effect of interregional competition.

[4]Price here refers to season's average price or the weighted average price for the entire season. For a complete discussion of the actual price equations, see reference (2).

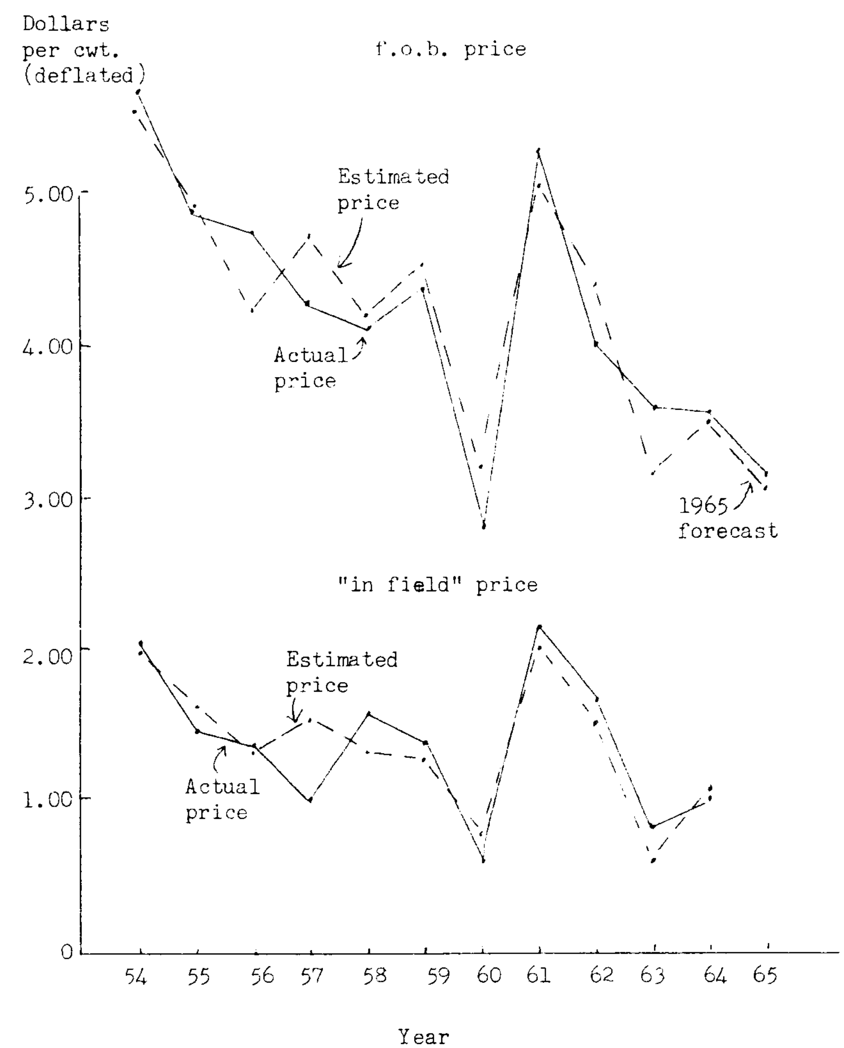

Figure 1. Season's average f.o.b. prices and "in field" prices received by Texas growers with prices estimated from multiple regression, all prices deflated by Consumer Price Index (1957-59 = 100), by years, 1954-1965.

RECOMMENDED PLANTED ACRES FOR WINTER CARROTS

Ideally, carrot growers would, as a group, plant and harvest that volume of carrots which would provide the maximum crop value each season[5]. The problem in attaining this "ideal" situation is twofold: (1) what acreage and yield in Texas will combine with production in California to provide a "reasonable" season's average price and (2) if growers had access to this type of information, could it be used effectively in the existing market structure?

In order to assist vegetable growers in making decisions designed to balance supply with market demand, the Consumer and Marketing Service (formerly Agricultural Marketing Service) of the U. S. Department of Agriculture issues *Acreage-Marketing Guides* (hereafter referred to as *AMG*) for selected vegetables by seasons and areas which contain recommended planted acreage for the forthcoming season. ((1) pp. 22-23).

Total winter carrot production exceeded recommended production on the average by 14 percent over the 1955-1965 period, Figure 2. The variability of the actual group yield relative to the expected yield is apparent. Variation in yields rather than in planted acreage caused most of the year-to-year variation in Texas' production and, thus, in the total production of winter carrots. However, the planting of acreage above the recommended level added to the frequent over-supply situation.

"EXPECTED" CROP VALUES FROM RECOMMENDED ACREAGES

"Expected" crop values were derived as follows: (1) recommended acreages for both Texas and California were multiplied by actual yields to get the "expected" total winter carrot production level in each area for each year, (2) these "expected" total production levels were used in the above mentioned price forecasting equation to estimate the Texas price associated with these production levels and (3) this price was multiplied by the "expected" Texas production level, yielding the "expected" Texas crop value for the year in question.

The major limitations involved in deriving the "expected" crop values were: first, the price equations derived from data on production, income, and population for the 11 year period, 1954-1964, "explained" only 75 percent of the annual variation in price around the long-term average; second, the yields used in developing expected production were assumed to be those actually experienced during the 10 years in California and in Texas; and, third, the effects of alternative crop enterprises on grower's carrot production activities were ignored.

[5] It would be expected that growers would attempt to maximize net crop value which involves both total returns and total costs; however, maximum gross crop value rather than maximum net crop value was used as the objective here.

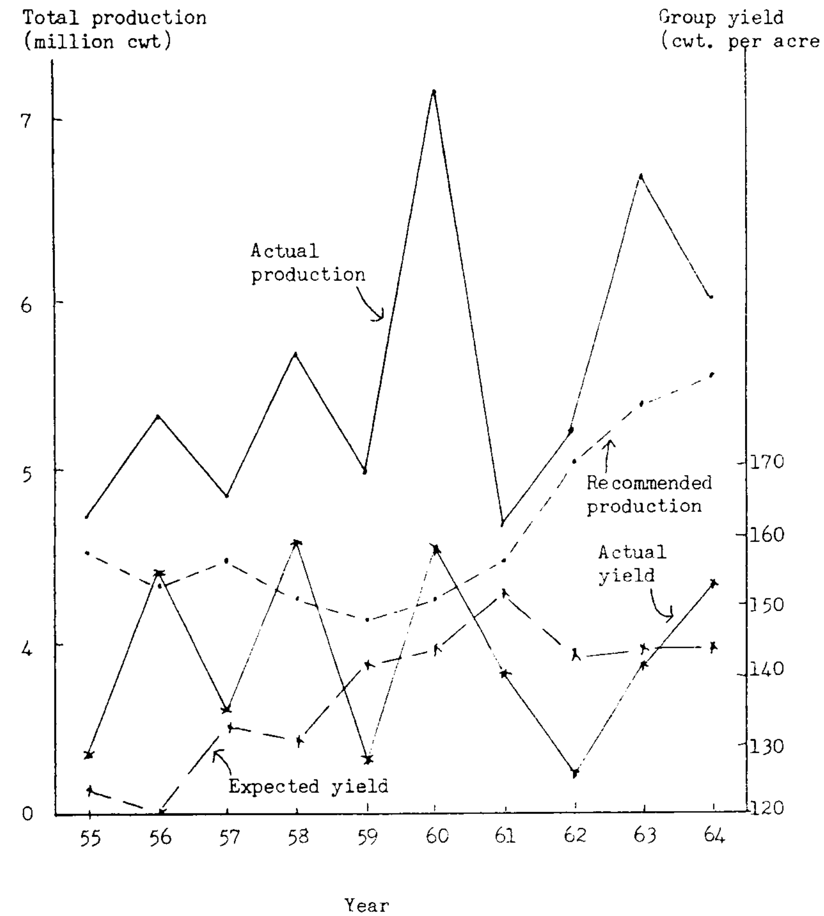

Figure 2. Total winter carrot production: actual production, expected production, actual yield and expected yield, 1955-64.

Data on actual acreages, production, prices and crop values are presented in the appendix table.

ACTUAL AND "EXPECTED" CROP VALUES COMPARED

"Expected" total crop values for Texas, when both Texas and California growers followed acreage recommendations, were greater than the actual total crop values in 7 of the 10 years, 1955-64, and averaged 13 percent higher than the actual average crop values, Table 1 and Figure 3. For example, had Texas production been about 870,000 hundredweight less in 1963 *and* had California also followed acreage recommendations, Texas "expected" price would have been around $1.90 (versus $0.86) and Texas "expected" total crop value would have approached 7 million dollars as opposed to the actual value of less than 4 million dollars, Table 1.

When California's actual production was substituted for the production expected from recommended acreages and actual yields in California, "expected" Texas crop values were greater than actual Texas crop values in only 5 years, or half of the 10-year period, and averaged only 7 percent higher than the actual average crop values.

A comparison between the actual crop values for Texas winter carrots and the "expected" crop values when both Texas and California followed the *AMG* recommendations suggests a net gain of 6,034,000 dollars in favor of the recommended acreage situations over the 10 crop years, Table 2. The large losses expected in 1958 and 1961 had recommended acreage been followed were largely due to California's actual acreage and resulting production being considerably lower than it would have been had California growers followed the *AMG* acreage recommendations.

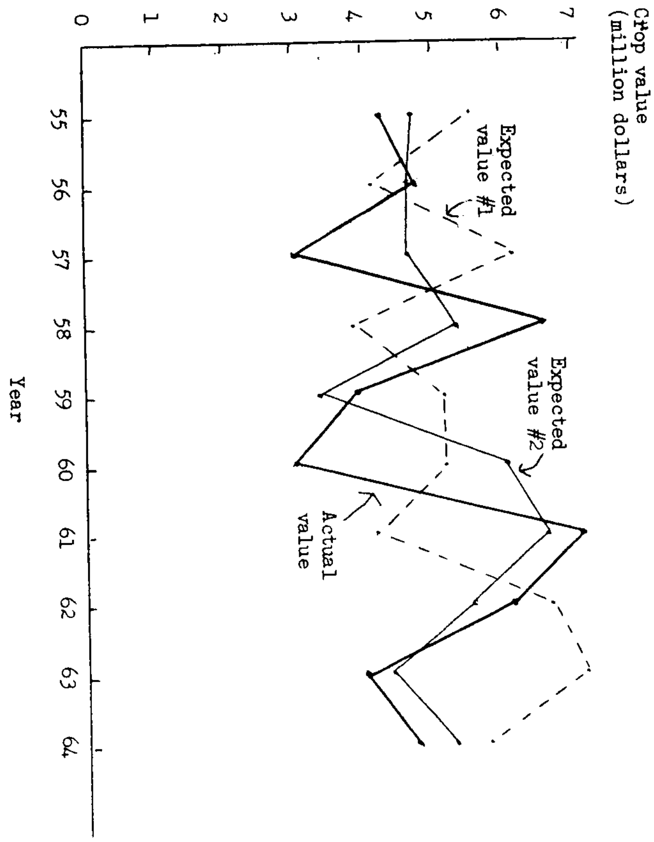

***Figure** 3.* Value of winter carrot crop to Texas growers; actual value, expected value #1 based on both Texas and California following acreage recommendations and expected value #2 with Texas following recommendations and California actual production, 1955-64.

Table 1. Texas winter carrots: reported price, production, and crop value and expected price, production, and value when: (1) both Texas and California followed acreage recommendations and (2) Texas followed the acreage recommendations and California had reported production levels, by years, 1955-1964. Actual yields were used in both situations.

Year	*Reported actual data for Texas*			*Expected prices and crop values to Texas growers from recommended acreage adjustments and actual yields*				
				Calif. and Texas both following acreage recommendations			*Texas following recommendations and Calif. at reported production levels*	
	Season price	*Production*	*Crop value*	*Price*[1]	*Production*	*Crop value*	*Price*	*Crop value*[1]
	(dollars per cwt)	(1,000 cwt)	(1,000 dollars)	(dollars per cwt)	(1,000 cwt)	(1,000 dollars)	(dollars per cwt)	(1,000 dollars)
1955	1.36	3,098	4,213	1.89	2,940	5,571	1.61	4,743
1956	1.26	3,780	4,777	1.08	3,783	4,075	1.24	4,686
1957	.97	3,080	2,990	2.09	2,926	6,130	1.60	4,688
1958	1.57	4,200	6,608	.87	4,363	3,801	1.22	5,334
1959	1.40	2,790	3,901	1.67	3,095	5,181	1.09	3,374
1960	.60	5,400[3]	3,000	1.14	4,543	5,161	1.33	6,056
1961	2.22	3,220	7,153	1.27	3,236	4,119	2.06	6,666
1962	1.75	3,490	6,116	2.42	2,735	6,633	2.02	5,535
1963	.86	4,620	3,985	1.90	3,746	7,122	1.16	4,333
1964	1.08[2]	4,410	4,763	1.33	4,322	5,747	1.21	5,219

[1] The predicted prices and resulting crop values were multiplied by the Consumer Price Index (1957-59 = 100), to get the expected values.

[2] Estimated from reported f.o.b. price. Season's average "in field" prices received by Texas growers were no longer available beginning 1964.

[3] Figure includes 400,000 cwt. produced but not marketed and not included in value.

Table 2. Actual crop values and "expected" crop values for Texas winter carrots assuming that both Texas and California growers had followed the recommended acreage adjustments and that acutal yields prevailed, 1955-1964.

Year	Actual crop value	Expected crop value	Expected results of following recommendations: Gain	Loss	Net
		(1,000 dollars)			
1955	4,213	5,571	1,358	....	
1956	4,777	4,075	....	702	
1957	2,990	6,130	3,140	....	
1958	6,608	3,801	....	2,807	
1959	3,901	5,181	1,280	....	
1960	3,000	5,161	2,161	....	
1961	7,153	4,119	....	3,034	
1962	6,116	6,633	517	....	
1963	3,985	7,122	3,137	....	
1964	4,763	5,747	984	....	
Total	47,506	53,540	12,577	6,543	6,034

The expected net crop values to growers would have increased relative to the expected total crop values because total production and marketing costs should have been less on the smaller number of acres.

Even though statistical tests at the usual levels of significance did not indicate that the "expected" crop values were significantly greater or less variable than the actual crop values, intuitively it appears that following the recommended acreages would have been desirable. First, the increase in net income would have been proportionately greater than the increase in total crop value because of the reduced production costs on the fewer total acres and, second, it is important to remember that in two of the three years when actual crop values were greater than the "expected" crop values, California's acreage and production were both actually *less* than the recommended levels. These two years, 1961 and 1958, were the largest and next-to-largest in terms of actual crop values during the 10-year period. Thus, reduced planted acreage would probably have increased net incomes to growers through both increased crop values and reduced production costs.

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(1) U. S. Department of Agriculture, 1965 Acreage-Marketing Guides—Winter Vegetables and Potatoes, AMG 39, Agricultural Marketing Service, August 1964.

(2) Carl E. Shafer, An Analysis of Sources of Variation in the Annual Value of South Texas Winter Carrot Crops. Departmental Technical Report No. 66-1, Department of Agricultural Economics and Sociology, Texas Agricultural Experiment Station, Texas A&M University, 1966.

Appendix Table. Statistics on winter carrots reported by the Statistical Reporting Service, U.S. Department of Agriculture: acreage, yield, production, price, and value of crop by years, 1954-1964.

Year	Acres planted: Texas	Calif.	Total	Acres harvested: Texas	Calif.	Total	Yield: Texas	Calif.	Group average
		(acres)			(acres)				
1954	29,000	6,300	35,300	28,000	6,300	34,300	95	260	125
1955	30,000	7,300	37,300	29,500	7,300	36,800	105	225	129
1956	28,500	6,400	34,900	28,000	6,400	34,400	135	240	155
1957	29,000	7,800	36,800	28,000	7,800	35,800	110	225	135
1958	32,000	5,600	37,600	30,000	5,600	35,600	140	265	160
1959	31,000	7,800	38,800	31,000	7,800	38,800	90	280	128
1960	36,000	8,900	44,900	36,000	8,900	44,900	150	195	159
1961	28,000	5,300	33,300	28,000	5,300	33,300	115	275	140
1962	35,500	6,500	42,000	34,900	6,500	41,400	100	265	126
1963	39,500	8,900	48,400	38,500	8,900	47,400	120	230	141
1964[4]	33,000	7,600	40,600	31,500	7,600	39,100	140	205	153

Sources: USDA, *Vegetables for Fresh Market; Acreage, Production, and Value*, 1854-58, Stat. Bull. No. 300, Statistical Reporting Service, Crop Reporting Board, Washington, D.C., De-cember 1761, pp. 50-54.

————————, *Vegetables-Fresh Market*, annual summaries for 1961-1964, published each December.

(continued on next page)

Appendix Table. (continued) Statistics on winter carrots reported by the Statistical Reporting Service, U.S. Department of Agriculture: acreage, yield, production, price, and value of crop by years, 1954-1964.[1]

Year	Production			Season average price received by growers[2]		Value		
	Texas	Calif.	Total	Texas	Calif.	Texas	Calif.	Total
	(1,000 cwt.)			(dollars per cwt.)		(1,000 dollars)		
1954	2,660	1,638	4,298	1.90	5.05	5,054	8,264	13,318
1955	3,098	1,642	4,740	1.36	3.95	4,213	6,483	10,696
1956	3,780	1,536	5,316	1.26	3.84	4,777	5,899	10,676
1957	3,080	1,755	4,835	.97	3.26	2,990	5,725	8,715
1958	4,200	1,484	5,684	1.57	4.80	6,608	7,125	13,733
1959	2,790	2,184	4,974	1.40	4.36	3,901	9,526	13,427
1960	5,400[3]	1,736[3]	7,136[3]	.60	3.20	3,000	4,368	7,368
1961	3,220	1,458	4,678	2.22	5.94	7,153	8,660	15,813
1962	3,490	1,722	5,212	1.75	4.93	6,116	8,492	14,608
1963	4,620	2,046[3]	6,667	.86	2.96	3,985	5,726	9,711
1964[4]	4,410	1,558	5,968	1.08[5]	4.39	4,763	6,846	11,609

[1] 1954-1959 figures are based on revisions after 1959 Census of Agriculture in Statistical Bulletin No. 300 listed on previous page. Figures for 1960-62 are for the previous year revisions reported in the current Vegetables-Fresh Market annual summary listed on previous page. Figures for both 1963 and 1964 are from the *Vegetables-Fresh Market* 1964 annual summary.

[2] Prices represent "in field" basis to Texas growers and "f.o.b." basis to California growers because these were reported to be the predominant methods of sale by growers in these respective areas.

[3] Includes some volume not marketed and excluded in computing value: 400,000 cwt. for Texas in 1960; 396,000 cwt. in 1960 and 110,000 cwt. in 1963 for California.

[4] Preliminary

[5] "In field" prices no longer reported for Texas beginning 1964: this price is an estimate. Texas prices are now reported on "f.o.b. price to grower" basis.

Processing Evaluation of Green Bean Varieties 1960 - 1964

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ABSTRACT

Seventeen varieties and 8 strains of green beans were evaluated on the basis of yield, sieve size, percentage seed, percentage crude fiber and color.

According to these tests, conducted over 7 seasons, Corneli 14, White Seeded Tendercrop and Bush Blue Lake should be good varieties for production and processing in the South Texas area. Slenderwhite variety should be included in future green bean evaluations.

INTRODUCTION

The production of green beans for processing is important to the vegetable growers in the Lower Rio Grande Valley. Increasing cost of production has caused some farmers to reduce their green bean acreage. New varieties of beans are being sought which will yield more tons of pods per acre and at the same time be acceptable as processed products.

Gould (1954) listed the more important characteristics required in selecting a suitable variety of green beans for processing. His recommendations are as follows: stringless and low in fiber content, long straight smooth pods, uniform dark green color, completely white seeded at maturity, uniform setting and maturation of pods, round pods with uniform bright flesh color and having the same flesh and pod wall coloring after processing, good flavor and odor, pods free of sloughing and small seeds completely surrounded by parenchyma tissue.

Two other very important factors, which may be classed as horticultural characteristics, must be considered by the processor is selecting a suitable variety of green bean for this area. It must produce consistently a high yield of pods per acre and have vine and pod characteristics suitable for machine harvest. Hollis, Kramer and Stark (1957) reported that some varieties set pods low in the plant and plants were sometimes small, thus reducing mechanical picking efficiency.

Hollis (1963) used 50 percent pods 4 sieve and under and 50 per-

[1] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

cent pods 5 sieve and over as the criteria of a good variety. The pods should, of course, be slow to develop seed and fiber and remain acceptable at advance stages of maturity.

Stephens and Correa (1960) presented information on yield and canning quality of several green bean varieties and strains for the years 1954 to 1958, and reported that Topcrop, Pearlgreen and Topmost could be recommended for the Lower Rio Grande Valley. Results reported in this paper are a continuation of information obtained on yield and canning quality of additional varieties and strains of green beans.

MATERIALS AND METHODS

Seven of the plantings of varieties were made at the Lower Rio Grande Valley Research and Extension Center, Weslaco, Texas, and one planting was made on the J. Richardson farm at Devine, Texas. Canning evaluations were made at the U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas. The varieties and strains of beans being tested were planted in a randomized block with 4 replications. Each plot consisted of 2 rows 35 feet long and 38 inches apart. The varieties of beans planted at Devine consisted of 3 replications with plots of 4 rows, 1000 feet long and 38 inches apart. Irrigation and other cultural practices were consistent and applied as needed during the growing season.

The varieties and strains grown at the Research and Extension Center were harvested 3 times during the season when they reached optimum maturities to produce the greatest tonnage of pods. There was one exception. The varieties and strains harvested the fall of 1962 were harvested only one time to simulate machine harvest. The beans grown at Devine, Texas, were harvested one time with a Chisholm-Ryder bean harvester when it was decided that the majority of the varieties and strains had matured their greatest tonnage of pods. It was necessary to harvest all pods at the same time in order to make comparisons among varieties and strains. The yield per acre reported in the tables is the mean of the 3 or 4 replications for the 1 or 3 harvest periods. The replications of each variety or strain were combined and size graded and the mean of the 3 harvest periods reported. The size grades for pods harvested the fall of 1962 and those at Devine, Texas, represent the combined replications of one harvest period.

A commercial size grader was utilized to segregate the pods into sieve sizes 1 to 3's combined, 4's, 5's and 6's and larger. Beans harvested the spring of 1961 were graded into 1 to 3's combined, 4's and 5's and larger. Size 6 and larger were combined with size 5 because of mechanical difficulty with the sizing equipment.

The processed quality evaluations of pods harvested the spring of 1960 and 1961 were made on pods from each of the 3 harvest periods. Sieve size 5 pods were used for the 1960 harvest and sieve size 5 and larger pods were used for the 1961 harvest. The processed quality evaluations reported for the pods harvested the other seasons were sieve size 5 pods from the second harvest only. The processed quality evaluations of pods harvested the fall of 1962 and those at Devine were made on one harvest.

Sufficient pods to fill 8 plain No. 303 (303x406) cans for each variety were sorted, snipped by hand and washed. The pods were blanched 3 minutes in water at 185 degrees F., vertically packed, 290 grams per can, then boiling 2% brine solution added and the cans closed with a minimum center-can-temperature of 170 degrees F. The cans of pods were processed 23 minutes at 240 degrees F. and cooled in tap water.

The processed quality of the pods was evaluated for percentage seed and percentage crude fiber in the pods, according to the U. S. Standards for Grades of Canned Green Beans and Canned Wax Beans (1961).

Color values were determined by use of a Gardner Color Difference Meter. Two hundred grams of beans were de-seeded and the pods blended with 50 ml. of distilled water for 3 minutes in a Waring Blendor[2]. The sample of blended pods was deaerated and the Gardner Rd, a, and b readings obtained after prior standardization of the instrument to the values for the standard color plate LGI, Rd 47.7, a −17.2 and b +5.5.

RESULTS AND DISCUSSION

The data for yield, sieve sizes, and processed quality of 17 varieties and 8 strains of green beans for a period of 1 to 7 seasons is summarized in Tables 1 and 2.

According to these data, the varieties which show special promise for production and processing in the South Texas area are Corneli 14, White Seeded Tendercrop and Bush Blue Lake.

Corneli 14 variety produces very smooth, straight pods which are as a rule low in crude fiber content. One season the canned pods of this variety had .15 percent crude fiber. This amount of fiber is almost too much for good canned green beans. The limiting rule for percentage crude fiber as established by the U. S. Standards for Grades of Canned Green Beans and Canned Wax Beans is .15 percent. The yield of pods of Corneli 14 is a little erratic from one season to the next, but the total yield is about the same as the average of the other varieties and strains.

White Seeded Tendercrop has long straight very smooth pods. It is inherently low in fiber content and does not produce excessive amounts of large sieve sizes. The 82.1 percent sieve size 4's and smaller

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2 Use of a company and/or product name by the Department does not imply approval or recommendation of the product to the exclusion of others whch may also be suitable.

Table 1. Yield, sieve sizes, and processed quality of green bean varieties grown at Weslaco, Texas.

Season, year and variety or strain	*Yield*	*Percent Sieve Sizes*				*Processed*				
						Seed	*Crude Fiber*	*Gardner*	*Color Notation*	
	lb/acre	*1-3's*	*4's*	*5's*	*6's & Lgr.*	*%*	*%*	*Rd*	*a*	*b*
Spring 1960										
Topcrop	9118	7.1	12.0	38.8	42.1	13.6	.08	16.6	—2.8	22.4
Topmost	7961	10.5	12.5	37.0	40.2	10.1	.05	17.2	—4.8	23.1
Pearlgreen	6968	12.2	21.6	53.3	12.9	11.7	.11	18.7	—5.0	24.2
Harvester	6420	38.2	40.8	18.4	2.6	17.3	.15	17.0	—5.4	23.5
Earligreen	7906	16.6	45.8	33.1	4.5	11.1	.19	20.8	—4.6	24.5
Tenderwhite	7296	13.6	35.7	40.3	10.4	7.8	.09	19.0	—5.0	24.0
Corneli 14	6110	15.2	37.8	40.2	6.8	9.7	.09	17.4	—5.3	24.1
Abunda	9090	10.6	13.2	51.1	25.1	11.1	.10	19.1	—5.2	24.3
Spring 1961										
Bush Blue Lake	3340	20.5	32.8	46.7	[1]	3.0	.03	15.6	—5.3	20.6
White Seeded Tendercrop	5241	13.2	31.8	55.0	----	5.9	.03	16.0	—5.7	21.4
Harvester C	3260	15.3	31.3	53.4	----	11.0	.07	17.8	—5.6	22.2
Pearlgreen	6134	9.0	19.6	71.4	----	5.3	.04	18.4	—5.5	21.6
Abunda	6338	9.0	16.0	75.0	----	4.5	.05	19.0	—5.4	23.4
Fall 1961										
Bush Blue Lake	9335	24.8	27.6	25.8	21.8	5.0	.03	16.0	—5.5	19.0
Topmost	8504	9.5	12.1	26.7	51.7	7.8	.04	18.1	—5.7	20.0
Harvester	7643	23.5	37.2	28.1	11.2	13.3	.12	18.4	—6.0	21.2
Pearlgreen	9464	11.3	18.2	39.4	31.1	7.7	.09	18.3	—5.8	21.2
B-3489	5664	22.3	31.3	29.8	16.6	10.2	.05	16.0	—6.0	21.7
B-3125-X-5-2	9493	18.6	31.7	29.3	20.4	8.7	.08	16.2	—6.0	21.1

Table 1 (cont.) Yield, sieve sizes, and processed quality of green bean varieties grown at Weslaco, Texas.

Season, year and variety or strain	*Yield*	*Percent Sieve Sizes*				*Processed*				
						Seed	*Crude Fiber*	*Gardner*	*Color Notation*	
	lb/acre	*1-3's*	*4's*	*5's*	*6's & Lgr.*	*%*	*%*	*Rd*	*a*	*b*
Spring 1962										
Bush Blue Lake	6281	20.8	24.8	41.9	12.5	8.0	.02	14.6	—6.2	21.0
Topmost	7146	11.9	12.7	30.0	45.4	8.3	.06	16.0	—5.9	21.1
Pearlgreen	8042	15.0	21.9	47.5	15.6	9.6	.16	17.7	—6.1	21.5
Abunda	8096	12.8	20.2	48.9	18.1	8.7	.16	16.7	—6.2	21.4
B-3125-2-3-1	3018	12.9	29.5	41.7	11.8	11.3	.26	14.3	—5.8	20.8
B-3489	1830	28.5	33.5	32.3	5.8	10.6	.10	16.2	—6.1	21.5
B-3125-X-5-2	6410	19.5	39.2	38.6	2.7	11.4	.15	16.0	—6.2	21.3
Corneli 14	6695	17.1	28.1	44.3	10.5	12.3	.15	16.0	—6.0	21.2
White Seeded Tendcrop	8975	16.6	32.5	45.1	5.8	9.2	.04	15.0	—5.7	21.1
Fall 1962										
Bush Blue Lake	1387	42.0	35.1	21.1	1.7	4.1	.04	16.3	—5.5	18.7
Topmost	4049	6.1	8.7	26.2	59.0	10.5	.06	18.3	—5.5	19.0
Pearlgreen	3159	11.1	14.1	45.9	28.9	9.5	.04	19.2	—5.5	22.4
Harvester	2177	16.5	34.0	40.2	9.3	9.1	.08	18.0	—5.6	22.0
B-3125-X-5-2	2901	21.2	35.0	38.7	5.1	12.0	.09	19.5	—6.1	23.1
Corneli 14	3303	15.3	33.1	45.0	6.6	10.6	.06	18.6	—6.4	22.3
White Seeded Tendcrop	2660	32.1	50.0	17.9	0.0	5.8	.04	17.8	—5.8	22.3
Green Pod 60204	4050	10.0	21.6	46.8	21.6	13.2	.08	19.1	—5.6	22.6
Improved Hygrade	4882	6.6	12.5	44.9	36.0	8.8	.03	21.3	—5.9	23.1

Table 1 (cont.) Yield, sieve sizes, and processed quality of green bean varieties grown at Weslaco, Texas.

Season, year and variety or strain	Yield lb/acre	Percent Sieve Sizes 1-3's	4's	5's	6's & Lgr.	Processed Seed %	Crude Fiber %	Gardner Rd	Color Notation a	b
Fall 1963										
Bush Blue Lake	5664	22.4	29.0	39.7	8.9	4.5	.04	14.4	—5.5	20.8
Pearlgreen	8081	9.9	15.7	49.0	25.4	10.2	.05	18.1	—5.3	21.8
White Seeded Tendcrop	6467	15.6	34.8	46.0	3.6	5.5	.07	15.1	—5.7	21.0
VIP	5808	19.2	29.3	45.6	5.9	6.4	.03	16.8	—5.5	21.3
Corneli 14	6553	17.2	40.4	37.2	5.2	10.8	.05	15.7	—5.4	21.3
Texas No. 1	6869	13.6	21.8	49.8	14.8	9.6	.02	16.6	—5.6	21.6
Blush Blue Lake-274	6467	20.2	29.3	38.1	12.4	4.7	.03	14.1	—5.3	20.3
Spring 1964										
Bush Blue Lake	4799	29.1	35.0	25.8	10.1	5.8	.06	15.9	—5.8	23.6
White Seeded Tendcrop	4076	19.3	32.8	40.7	7.2	6.7	.03	16.2	—6.1	23.9
Corneli 14	5590	17.5	31.1	36.9	14.5	8.0	.06	17.0	—6.4	23.8
B-3125-X-5-2	7534	20.5	37.0	38.0	4.5	7.8	.04	17.3	—6.1	24.0

[1] Sieve sixe 6 and larger were combined with sieve size 5.

Table 2. Yield, sieve sizes, and processed quality of green bean varieties grown at Divine, Texas.

Season, year and variety or strain	Yield lb/acre	Percent Sieve Sizes 1-3's	4's	5's	6's & Lgr.	Processed Culls %	Seed %	Crude Fiber %	Gardner Rd	Color Notation a	b
Fall 1966											
Bush Blue Lake	4320	22.0	37.0	25.0	3.0	13.0	3.4	.03	14.6	—5.6	20.8
Topmost	4646	11.0	21.0	43.0	10.0	15.0	7.0	.04	18.2	—6.3	22.4
Abunda	2916	28.0	28.0	25.0	1.0	18.0	6.2	.06	18.1	—6.0	22.2
Executive 1070	3957	13.0	35.0	31.0	4.0	17.0	5.0	.04	16.9	—5.7	21.5
Improved Hygrade	5251	5.0	10.0	44.0	31.0	10.0	5.6	.09	18.1	—5.9	21.3
Gallatin Valley No. 50	6606	10.0	27.0	45.0	2.0	16.0	6.5	.04	15.2	—5.7	20.9
Greenpod 60209	5772	6.0	29.0	46.0	2.0	18.0	13.8	.12	17.6	—5.4	21.5
VIP	4356	11.0	26.0	31.0	1.0	31.0	6.4	.02	15.5	—5.4	21.1
Slenderwhite	8058	10.0	64.0	11.0	0.0	15.0	10.6	.03	17.5	—6.0	21.8
Slimgreen	6316	15.0	74.0	2.0	0.0	9.0	10.1	.05	[1]	...	...
Corneli 14	5385	13.0	38.0	32.0	1.0	16.0	8.3	.03	16.4	—6.1	21.3
Executive	5336	13.0	38.0	33.0	1.0	15.0	7.6	.02	15.5	—5.3	20.8

[1] Sample lost.

produced the fall of 1962 is probably due to the pods being harvested at an immature stage of development.

The canned pods of Bush Blue Lake have very little fiber, the color is excellent and the pods are firm. The dark green color and the firmness of the canned pods of this variety are its outstanding characteristics. The Gardner color notation for this variety shows that for every season tested it was as dark or darker green than the other varieties and strains. Unfortunately it does not produce consistently a large crop of pods and sometimes the pods produced are rough.

Bush Blue Lake – 274 strain has all the best characteristics of the Bush Blue Lake variety and in addition produces smoother pods[3].

The other varieties and strains tested either failed to consistently meet the necessary requirements for production and processing or they require further testing before acceptance or rejection. Some examples are Tenderwhite and B-3125-X-5-2 which are better adapted to a soil type that is acid. They will not consistently develop vines and set pods in the alkaline soils of the South Texas area. Harvester variety, in addition to producing pods with excess crude fiber, has a brittle vine. It is difficult to sieve size the variety efficiently because clusters of pods break from the vine rather than single pods and the clusters hang together through the sizing equipment. Varieties such as Abunda and VIP cannot be mechanically harvested efficiently because of small type bushes with pods that set low in the bush.

Slenderwhite variety should be included in future trials because it is a good producer of small pods. The canned pods have fairly good color, are straight, smooth and low in crude fiber.

The development of seed in the pods was not excessive for any of the varieties and strains evaluated. The limiting rule for percentage seed in the pods as established by the U. S. Standards for Grades of Canned Green Beans and Canned Wax Beans (1961) stipulates the trimmed pods contain not more than 25 percent by weight of seeds and pieces of seeds.

The seed for varieties of beans with higher total yields per acre is one major factor restricting green bean production for processing in the South Texas area. Processing qualities are not as a rule the limiting factors which attribute to the rejection of varieties. The majority of varieties in these tests would make good to excellent canned products.

There are exceptions. Topcrop variety for instance which was one of the varieties recommended by Stephens and Correa (1960) is no longer planted in this area because the pods contain brown colored seed which cause discoloration in the liquor of the canned products. The other two varieties, Topmost and Pearlgreen, which were recommended are no longer grown, but not altogether because of their processing characteristics. The pods of Topmost develop too rapidly and produce too great a percentage of large pods. Pearlgreen matures rapidly most seasons and develops too much fiber.

[3] The strain Bush Blue Lake – 274 is now offered to growers as Bush Blue Lake Variety. The old Bush Blue Lake Variety has been discontinued.

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Blossom-end Rot of Pear Shaped Tomatoes[1]

C. J. GERARD[2]

Blossom-end rot is described as a physiological disorder of tomatoes. According to Spurr (1959), Geraldson (1957) and others, blossom-end rot becomes first apparent as a water-soaked area under the fruit wall on the blossom-end. This water soaked area eventually turns into a blackened, dry, sunken spot. Factors which have been reported to enhance the incidence of blossom-end rot are: unfavorable weather conditions, applications of potassium and ammonium fertilizers, soil moisture stress and insufficient calcium in the soil solution and plant parts.

As stated by Spurr (1959), the two principal causes suggested for blossom-end rot are moisture stress and calcium deficiency. Raleigh (1939) postulated that blossom-end rot is due to some moisture relation rather than inability of plants to obtain sufficient calcium. However, Geraldson (1957), Maynard et al (1957), and Spurr (1959) reviewed much of the previous literature and presented evidence to support the concept that calcium deficiency is the fundamental cause of blossom-end rot.

Results of investigations evaluating the influences of moisture levels, spacings, soil amendments and soil type on yield and growth characteristics of pear tomatoes do not support the concept that calcium deficiency is the fundamental cause of blossom-end rot in the Lower Rio Grande Valley. This paper discusses these results and their possible contributions to an understanding of blossom-end rot of pear tomatoes.

PROCEDURES

Moisture level studies on tomatoes were conducted from 1958 through 1965. Moisture level studies were conducted on medium-textured soils, Laredo clay loam and Willacy loam soils, from 1958 through 1964. A moisture level, nitrogen and soil amendment study was conducted on a fine-textured soil, Harlingen clay, in 1965. The moisture level treatments, which are described in Table 1, were either in randomized block or Latin square designs. The moisture treatments were usually split to include fertility, amendment or spacing variables. Moisture treatments were based on available water in the top 2 feet of soil. Blossom-end rot incidence was expressed on weight basis in 1963 and 1964 and by percentage of affected fruits in 1965. The calcium contents of leaves and fruits of normal and BER[3] pear and normal cherry tomatoes grown under different moisture levels, nitrogen fertilization and amendment treatments were determined with an Aztec Atomic Absorption Spectrophotometer. Plant materials were ashed and brought into solution with 5 ml of concentrated HCL and HNO_3 and diluted to 100

[1] Presented before Rio Grande Valley Horticultural Society on January 25, 1966, at Weslaco, Texas.

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Table 1. Description of moisture level and amendment treatments on Harlingen clay soil in 1965.

	Percent of moisture at maximum allowable stress
Soil Moisture (Main treatments)[1]	
Before the bloom stage, tomatoes in all moisture treatments were irrigated when the moisture content of the top 2 feet of soil was depleted to 25 percent of the available moisture. Moisture treatments B, C and D were initiated after the bloom stage.	
A. No water was applied after the bloom stage	
B. Irrigation brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 50 percent of the available moisture.	25
C. Irrigation brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 25 percent of available moisture.	23
D. Irrigaion brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 0 percent of available moisture.	21
Soil Amendment Treatments	Nitrogen treatments # N/A
1. Check.	0
2. 2000 #/A gypsum	100
3. 2000 #/A sulfur	200
	300

[1] All moisture levels received a preplanting irrigation and were irrigated on the basis of changes in average available moisture of the top 2 feet. Field capacity is approximately equal to 31 percent; 15-atmosphere tension is approximately equal to 21 percent.

[3] Abbreviation for blossom-end rot.

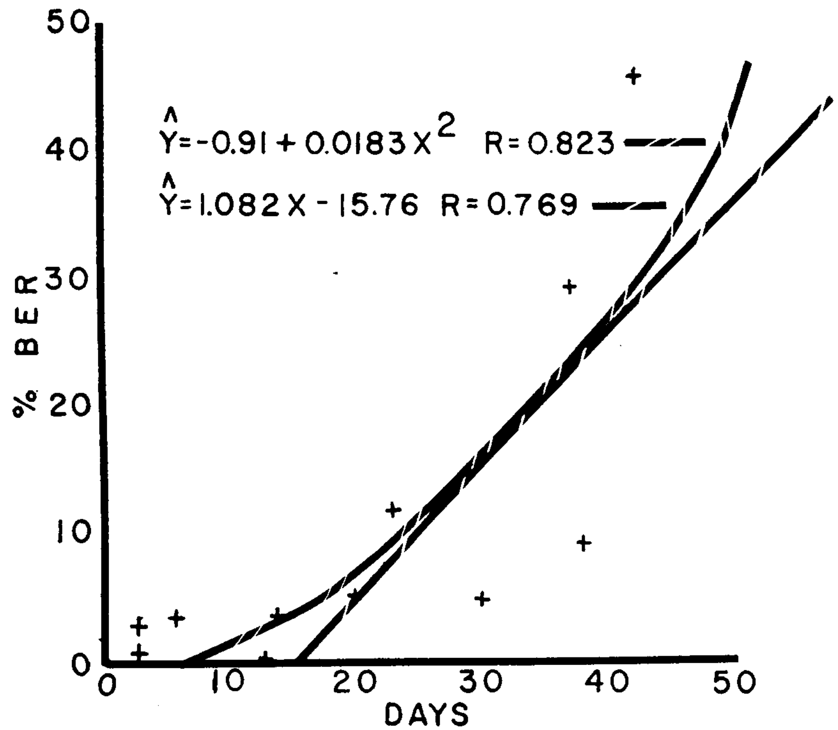

Figure 1. Relationship between % BER of Chico tomatoes and number of days after initiation of blooming prior to irrigation or significant rain (> 0.5") on medium-textured soils. The linear equation includes only tomatoes which were subjected to 10 or more days of stress.

ml. Enough $SrCl_2$ was added to unknown, check and standard solutions to make solutions containing 2500 ppm of Sr^{++}. Addition of Sr^{++} prevents interference of phosphate in calcium determinations.

RESULTS

FIELD DATA

Medium-Textured Soils

Round type tomatoes[4] from 1958-60 and Chico (small pear variety) in 1962 did not have any incidence of blossom-end rot. The relationship between blossom-end rot of Chico tomatoes on medium-textured soils and number of days of moisture stress in the primary root zone (top 2 to 3 ft.) after initiation of blooming is parabolic as indicated in Fig. 1; the intercept or zero percent BER, occurs at 7 days. The relationship between BER of Chico tomatoes and number of days of stress above 10 days after initiation of blooming is primarily linear as indicated in Fig. 1. Note that the intercept is between 14 and 15 days. According to the linear equation for every day of stress past 15 days there was an increase of about one percent in blossom-end rot. This would suggest the need to irrigate Chico tomatoes no later than 7 to 15 days after initiation of blooming to keep blossom-end rot at a low level of incidence (<5%). Spurr (1959) found that incipient stages of blossom-end rot occur from 12 to 15 days after anthesis. The Chico and Chico Grande[5] tomatoes like the San Marzano tomato described by Spurr (1959) grow rapidly during the 9 to 15 days following anthesis. Spurr (1959) states that the disorder occurs during the relatively active phase of growth and in some way is probably correlated with fruit development.

Close spacing tended to increase blossom-end rot in 1963-64. Soil applied calcium chelate did not decrease incidence of BER in 1964.

Fine-Textured Soil

Results of the 1965 moisture level-N variable study on fine-textured soil are summarized in Table 2. Rains of about 3.2 inches between 5/17 and 5/20 considered equivalent to one irrigation probably reduced the BER incidence on the dry treatments (A and D). On June 1 BER incidence for tomatoes grown under treatment A, C and D were not significantly different, but tomatoes grown under treatment B had a lower BER incidence. Blossom-end rot incidence was about 4 times higher on June 15 than on June 1. The June 15 and total BER data showed a significant inverse relationship with numbers of irrigation.

The influence of N variables on BER is also indicated in Table 2. Applications of 200 and 300 pounds of nitrogen per acre caused a sharp increase in BER. High nitrogen rates probably depleted available water faster, and promoted more succulent growth. Spurr (1955) and Geraldson (1957) pointed out that factors which favor rapid growth enhanced BER.

The primary root system of annuals on this fine-textured soil is restricted to the top foot. Because of its high water holding capacity, the soil is cooler in the spring. The cooler soils delay growth and fruiting of tomatoes and cause a significant part of fruit production of spring-planted tomatoes to occur during late May and June when evaporative demands are high in the Lower Rio Grande Valley. Frequent light irrigations must be applied to keep a high level of moisture in the primary root zone. Evaporative demands in May and June were so great that stress was evident even under high moisture treatments. A restricted root system was partly responsible for the inability of plants to maintain tugor even under high soil moisture conditions.

[4] Varieties Homestead and Rio Grande.

[5] Chico Grande is a large pear shaped tomato.

Table 2. Influence of moisture levels, fertilization and amendment treatments on incidence of blossom-end rot of pear tomatoes on a Harlingen clay soil at different times of growing season.

Time of Evaluation	Moisture Level Treatments				Nitrogen treatments # N/A				Amendment treatments	
	A	B	C	D	0	100	200	300	Gypsum 2000 #/A	Sulfur 2000 #/A
	% Blossom-End Rot									
June 1	12	6	11	17	9	14	13	15	10	9
June 15	47	28	37	41	32	32	42	45	39	39
June 22	47	34	44	47	36	41	48	46	41	44
June 29	28	13	17	19	15	16	26	21	19	20
Average June 1-29	39	22	30	33	25	27	37	34	29	32

Additions of soil amendments, gypsum and sulfur, tended to increase BER possibly by increasing the osmotic pressure of soil solution and therefore reducing the available water in the surface foot of soil.

The calcium contents of normal and BER pear and normal cherry tomatoes as influenced by moisture, nitrogen and amendment treatments are indicated in Table 3. These data do not show any relationship between calcium contents of fruits, stems and leaves and BER incidence. Blossom-end rot fruits were slightly higher in calcium than normal fruit as indicated in Table 3. This trend is different from the data reported in the literature. Calcium contents of leaves and stems of cherry tomatoes were lower than calcium contents of leaves and stems in pear tomatoes. The calcium content of leaves and stems was about 20 times higher than calcium content of fruit. These results would not indicate that calcium is the fundamental cause of BER of pear tomatoes in the Lower Rio Grande Valley. However, the calcium data and the reported data by Spurr (1959) would give indirect evidence of higher osmotic pressure of leaves and stem.

DISCUSSION

Relationships between incidence of BER of pear tomatoes and moisture stress indicate that BER develops between 7 to 15 days after anthesis which agrees with data by Spurr (1959). Incidence of BER on fine-textured soils was inversely related with numbers of irrigations; nitrogen fertilization increases BER of pear tomatoes. Spring-planted tomatoes grown on fine-textured soils develop higher BER incidence even under high moisture level conditions. Tomatoes grown on fine-textured soils develop a shallow root system and produce a great part of the crop under high evaporative conditions. In contrast, fall-planted pear tomatoes on medium and fine-textured soils usually have low BER probably because production occurs under low evaporative demand conditions.

Chemical analyses of fruits do not indicate that calcium deficiency is the fundamental cause of BER of pear tomatoes. Data reported by Spurr (1959) and data obtained at Weslaco (1965) indicate that fruits have lower osmotic pressure; this would suggest that moisture transfer from fruit to other plant parts could be expected under high moisture stress or high evaporative conditions.

From the field, laboratory and literature data it seems that factors which influence transpiration and transfer of water from fruits to other plant parts such as cell permeability, solar radiation, available soil moisture and osmotic pressure of fruit and plant influence BER incidence. Factors such as growth rate, N-fertilization and calcium contents play significant roles in cell permeability, osmotic pressure of fruit, and available soil moisture and therefore influence BER incidence.

The primary cause of BER in pear tomatoes appears to be loss of water due to transpiration and/or loss of water from the blossom-end

Table 3. Influence of moisture level, nitrogen and amendment treatments on calcium content of pear and cherry tomato fruits.

Sub-treatments	Moisture treatments								
	Pear tomato								Average
	A		B		C		D		
	Normal	BER*	Normal	BER*	Normal	BER*	Normal	BER*	
	% Calcium								
0# N/A	0.13	0.16	0.11	0.17	0.09	0.13	0.13	0.12	0.13
100# N/A	0.14	0.10	0.10	0.17	0.10	0.15	0.09	0.11	0.12
200# N/A	0.14	0.18	0.15	0.17	0.12	0.15	0.12	0.18	0.15
300# N/A	0.13	0.17	0.12	0.16	0.15	0.15	0.11	0.11	0.14
Gypsum 2000#/A**	0.18	0.17	0.18	0.14	0.17	0.19	0.08	0.12	0.15
Sulfur 2000#/A**	0.12	0.20	0.14	0.24	0.09	0.15	0.10	0.14	0.15
Average	0.14	0.16	0.13	0.18	0.12	0.15	0.11	0.13	
	Cherry tomato % calcium								
300# N/A	0.19		0.18		0.15		0.12		0.16

* BER fruits were significantly higher in calcium than normal fruits at .05 level

** Gypsum and sulfur treated plots received 100# N/A.

of pear fruits to other parts of plants. Further investigations to clarify the proposed hypothesis are contemplated.

SUMMARY

From the relationship between % incidence of BER and moisture stress it was determined that spring-grown pear tomatoes should be irrigated 7 to 15 days after initiation of first bloom to keep BER incidence below 5% on medium-textured soils. Moisture stress and nitrogen fertilization increased BER on fine-textured soils. However, moisture stress conditions and high BER incidence occurred even under high soil moisture conditions because a good part of the production of spring-grown tomatoes occurred under high evaporative conditions (June). In contrast, fall-planted pear tomatoes grown on medium and fine-textured soils have low BER incidence probably because production occurs under low evaporative demand conditions. Since spring production of pear tomatoes on fine-textured soil often means high BER incidence, production of pear tomatoes on these soils probably should be restricted to fall production.

A hypothesis is proposed to explain BER in pear tomatoes. The primary cause of BER in pear shape tomatoes appears to be loss of water from blossom-end of fruit during its active growth stage. Blossom-end rot probably occurs from transfer of water from fruit to atmosphere (transpiration) and to other plant parts. The transfer of water to other plant parts may be the most significant mechanism involved, particularly under conditions of high moisture stress such as occur on fine-textured soils. However, further investigations will be needed before this can be substantiated.

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Citrus Varieties for Ornamental Plantings in South Texas

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ABSTRACT

Citrus varieties and relatives suitable for ornamentals in South Texas include 5 lemon-lime types, 4 kumquats, calamondin, 2 kumquat hybrids, 'Chinotto' and 'Bouquet de Fleur' sour oranges, 6 tangerines, 'Sinton' citrangequat, 'Flying Dragon' *(Poncirus trifoliata)*, *Eremocitrus glauca*, and *Severinia buxifolia*. Fruit season, size, color, and flavor; cold hardiness; and use in landscaping are described.

INTRODUCTION

The commercial grapefruit, sweet orange, and tangerine varieties with large, edible fruits are generally attractive and suited to backyard plantings. However, some citrus varieties and relatives with inedible or small fruits are valued primarily for ornamental use. Most ornamental citrus trees have small, brightly colored fruits which remain on the tree for extended periods. Sour or inedible fruits often remain longer than edible fruits, especially when small children are present. Many kinds of citrus trees flower several times a year, and a tree may have flowers, green fruit, and ripe fruit simultaneously. Ornamental citrus varieties are sometimes grown in pots or tubs and sold when the plants carry from two to several dozen fruit. The purpose of this article is to acquaint the home grower with several citrus varieties available for him to plant as ornamentals.

VARIETIES SUITABLE AS ORNAMENTALS

Most of the varieties suitable as ornamentals for South Texas (Table 1) are described in detail by Webber (1946) and Swingle (1946). Bitters (1947) described many of them for use in California. One or more trees of each kind is being grown in test plots at the Experiment Station at Weslaco, or at Rio Farms, Inc., Monte Alto. Many were introduced as seed or budwood from USDA laboratories at Indio, California, and Orlando, Florida.

The Meyer lemon is tristeza-free, but carries "tatter leaf" virus. The 'Sinton' citrangequat and *Eremocitrus glauca* were not tested extensively for viruses, but they are free of tristeza virus. The trees of remaining varieties in the test plots are either virus indexed or nucellar seedlings and are considered free of viruses causing psorosis, tristeza, exocortis, and xyloporosis.

Most of the varieties in Table 1 are small trees or large shrubs. The kumquats are dwarfed shrubs, especially when grown on *Poncirus trifoliata* rootstock. The selections in Table 1 range in hardiness from relatively tender lemons, Rangpur and Kusai "limes" to medium hardy Chinotto, *Severinia buxifolia*, calamondin, and limequat. The hardiest kinds are the mandarins, 'Sinton' citrangequat, kumquats, and *P. trifoliata*. When dormant, *P. trifoliata* is extremely cold hardy. On the east coast it grows as far north as Boston.

The reddest fruit occurs on 'Sinton' citrangequat, originally selected at Sinton, Texas. The intensity of peel color in 'Sinton' and other varieties varies from season to season. Peel color is usually lighter in the Lower Rio Grande Valley than in the Crystal City area, where nights are generally cooler.

Breeding work to find better citrus ornamentals is now in progress at the U. S. Date and Citrus Station, Indio, California, and at Weslaco.

USE OF CITRUS IN LANDSCAPE PLANTING

Citrus and citrus relatives are useful for special purposes in a landscaping plan.

For a hedge, *Severinia buxifolia*, with its round and leathery leaves, can be a useful substitute for box *(Buxus sempervirens)*. Chinotto orange can also be pruned to a hedge. Thorny *Poncirus trifoliata* may be dangerous where children run and play.

For plantings adjacent to a house or building, dwarfed plants such as kumquats and *Severina buxifolia* may be considered.

For a shade tree, as in patios in Laredo, the sour orange is valuable. An uncommon sour orange type that could be used includes 'Bouquet des Fleurs' which has dense foliage that tends to cluster.

For a corner accent, Chinotto orange, a small-fruited mandarin, or kumquats are suitable.

Individual specimen trees with attractive fruit include: 'Sinton' citrangequat, 'Chinotto' orange, calamondin, 'Cleopatra' mandarin, Ponderosa lemon and lemonquat. Many yards also use grapefruit, sweet orange, or tangerine trees for edible and ornamental fruits.

For pot plants with fruiting trees, 'Meyer' lemon, lemonquats, kumquats, Ponderosa lemon, limequats and calamondin have been used in Texas.

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Table 1. Citrus varieties suitable for ornamentals in South Texas.

Group and variety	*Fruit size (in.)*	*Peel color*	*Flavor*	*Cold-hardiness*	*Ripening dates*	*Comments*
LIME-LEMONS						
'Mexican' lime	1	yellow	acid	poor	year-round	Heavy ripening in August.
'Ponderosa' lemon	6	yellow	acid	poor	year-round	Heavy ripening in August.
'Meyer' lemon	3	yellow-orange	acid	fair	year-round	Heavy ripening in August, September.
'Kusaie' "lime"	2	yellow	acid	poor	Oct.-May	Heavy ripening in fall.
'Rangpur' "lime"	2	orange	acid	poor	Oct.-May	Fruits like tangerine, heavy ripening in fall.
KUMQUAT HYBRIDS						
' 'Eustis' limequat[ab]	1	lemon	acid	fair	year-round	A cold-hardy lime substitute.
'Lemonquat'[ab]	2	lemon	acid	good	year-round	A cold-hardy lemon type.
Calamondin[ab]	1	orange	acid	good	year-round	Showy, attractive fruits, popular, and a lime substitute.
SOUR ORANGES						
Sour oranges	3	orange	acid	good	Oct.-May	Commercial rootstock.
'Chinotto'	2	orange	acid	good	Oct.-May	Fine-textured foliate; attractive, semi-dwarfed tree.
'Bouquet des Fleurs'	3	orange	acid	good	Oct.-May	Closely-spaced leaves.
KUMQUATS *(Fortunella)*						
'Meiwa'[a]	1	orange	mildly acid	very good	year-round	Dwarfed shrub; edible peel, oval fruit.
'Nagami'[a]	1	orange	mildly acid	very good	year-round	Dwarfed shrub; edible peel, elongated fruit.
F. Obovata[a]	2	orange	mildly acid	very good	year-round	Inroduction from Japan, ovate fruit.
F. Hindsii[a]	1/4	orange	inedible	fair (?)	year-round	Fruits in pots as 1-year-old seedling.

(Table 1 continued)

Group and variety	*Fruit size (in.)*	*Peel color*	*Flavor*	*Cold-hardiness*	*Ripening dates*	*Comments*
MANDARINS & HYBRIDS						
'Clementine'	2	reddish orange	good	very good	Nov.-Dec.	Semi-commercial tangerine.
'Cleopatra'	1	orange	acid	very good	Mar.-Apr.	Seedy rootstock.
'Dancy'	2	red-orange	good	fair	Jan.	Fruits numerous, conspicuous. Better flavor than Clementine.
'Fairchild'	2	reddish orange	very good	not known	Nov.-Dec.	A new variety.
'Orlando'	3	yellow-orange	good	very good	Dec.-Jan.	Semi-commercial tangelo.
'Timkat'	1	yellow	good	very good	Mar.-May	Fruits numerous, conspicuous.
PONCIRUS TRIFOLIATA						
'Flying Dragon'	1	yellow	bitter	very good	Oct.-May	Conspicuous flowers, inconspicuous fruits; wicked thorns curve down and branches are successional curves.
CITRANGEQUAT						
'Sinton'	1	scarlet	inedible	very good	Nov.-Apr.	Cold-hardy, conspicuous fruit.
EREMOCITRUS						
E. glauca	...	....	inedible	very good	....	Grey-green, leathery foliage; leaves like thin spaghetti; from Austrailian desert.
SEVERINIA						
S. buxifolia	1/2	black	inedible	good	Spring, summer, fall.	This "box-leaved orange" is resistant to salt, is used as hedge, and sometimes as a rootstock for kumquats; sometimes chlorotic on calcareous soils.

[a] Grown on 'Cleopatra' mandarin or calamondin rootstock in Lower Rio Grande Valley; grown on *Poncirus trifoliata* rootstock in other areas.
[b] Grown as cutting on its own roots.

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Phenology of the Corn Earworm and Cabbage Looper as Related to Spring Lettuce in the Lower Rio Grande Valley

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ABSTRACT

The number of preimaginal stages of the corn earworm *Heliothis zea* (Boddie) and cabbage looper *Trichoplusia ni* (Hubner) was determined at weelky intervals on late planted lettuce. Egg deposition by the corn earworm began about February 16. Maximum infestation by both species occurred on March 9.

INTRODUCTION

The growing season of the lettuce crop has extended into late March and early April since the development of Valverde lettuce. As a result the corn earworm, *Heliothis zea* (Boddie), has become the limiting insect factor while damage from the cabbage looper, *Trichoplusia ni* (Hubner), has increased also. Wolfenbarger and Getzin (1962) and Schuster (1966) have shown that insecticidal control of the corn earworm is possible but that timing is very important since larvae must be killed before penetration of the lettuce head occurs.

The relation of certain pests to the stage of growth in which the plant host may be attacked, are usually linked. This relationship or phenology is of considerable importance for fixing the time of the treatment, (Frassen 1959). In this paper, the author wishes to show that in fixing the most favorable time of applying controls to lettuce in the Lower Rio Grande Valley, the phenology of the insect as well as the growth stage of the plant host must be considered.

PROCEDURES

Lettuce was planted at different intervals beginning in September 1960. Different varieties were used but the variety Valverde was planted in the last week of December in 1960 and 1961. Populations of bollworms and cabbage loopers were determined by examining 10 to 20 lettuce plants weekly through the season until February 8, 1963. The number of eggs and larvae of the corn earworm and cabbage looper were recorded and the percentage plants infested was determined. The location of each egg on the leaf surface was recorded as adaxial or abaxial.

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RESULTS

Corn earworm eggs were not found until February 23. The first instar larvae move along the mid-rib as they migrated into the lettuce head. Once inside the head they were impossible to contact with foliar applied insecticides. Although the number of eggs per plant was more than one per plant the number of larvae per plant was never greater than one per plant. This was apparently due to the cannibalistic nature of the larvae. Rarely was more than one of the larger instar larva found within the head. The data in Table 1 indicate that egg deposition began about February 23 on late-planted lettuce. In 1963 no eggs had been found on February 8 when the study ended. Data secured over a 3-year period indicate that earworms would not be a problem on late planted lettuce until late February during most years.

During this study, earworm egg deposition on lettuce declined sharply after October. However, earworm larvae were found in lettuce in December 1962, December 1963 and January 1964 on the more mature lettuce. The two winters were mild without killing freezes in November and December and apparently the mature lettuce was attractive to moths for egg deposition. Moths have been caught in light traps at Weslaco during all months of the year (unpublished data). It appears that young lettuce growing during January and February are not as attractive to moths when moth activity is slowed during these colder months.

Cabbage looper eggs were not found on lettuce plants until February 16 (Table 2). Looper larvae were found one week earlier than corn earworm larvae; however, the total population was never as great. Looper larvae were found during every month of the year during the period of this study. The looper populations followed a trend similar to that of the corn earworm in that they were greater in number in the fall; declined during the cooler part of the winter, and increased after February. The infestations of looper on lettuce was found to be of a random nature when correlations were calculated for looper per plant and plants infested. The value found for r was +.96.

Corn earworm eggs were laid predominantly on the adaxial surface. This became even more pronounced as the leaves began to form the head. Cabbage looper eggs were more randomly distributed over the plant. There is a significant difference in location only on March 9 on which date most plants were well headed.

Table 1. Average number of corn earworm eggs and larvae found on lettuce planted in December 1960, 1961.

Sample	Plants infested	Eggs/	Larvae/	Eggs position leaf surface		Total
date	Percent	Plant	Plant	adaxial	abaxial	eggs
Feb. 2	0	0	0	0	0	0
Feb. 9	0	0	0	0	0	0
Feb. 16	0	0	0	0	0	0
Feb. 23	2.5	.03	0	1	0	1
March 2	35.0	.95	.5	26	12	38
March 9	70.0	1.40	.23	43	10	53
March 16	67.5	1.50	.35	18	8	36
March 23	80.0	1.60	.90	22	9	31
March 30	70.0	1.40	.95	21	7	28

Table 2. Average number of cabbage looper eggs and larvae found on lettuce planted in December 1960, 1961.

Sample	Plants infested	Eggs/	Larvae/	Eggs position leaf surface		Total
date	Percent	Plant	Plant	adaxial	abaxial	eggs
Feb. 2	0	0	0	0	0	0
Feb. 9	0	0	0	0	0	0
Feb. 16	2.5	.05	0	1	0	1
Feb. 23	17.5	.11	.03	2	4	6
March 2	15.0	.11	.07	7	1	8
March 9	70.0	1.40	.07	49	5	54
March 16	47.5	.55	.28	3	8	11
March 23	60.0	.65	.31	8	5	13
March 30	50.0	.80	.36	4	12	16

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