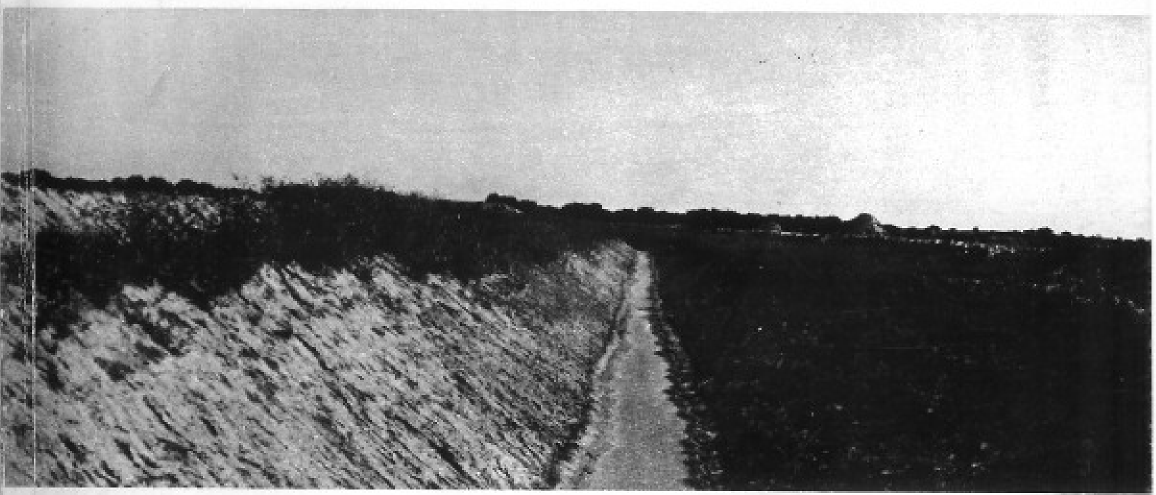
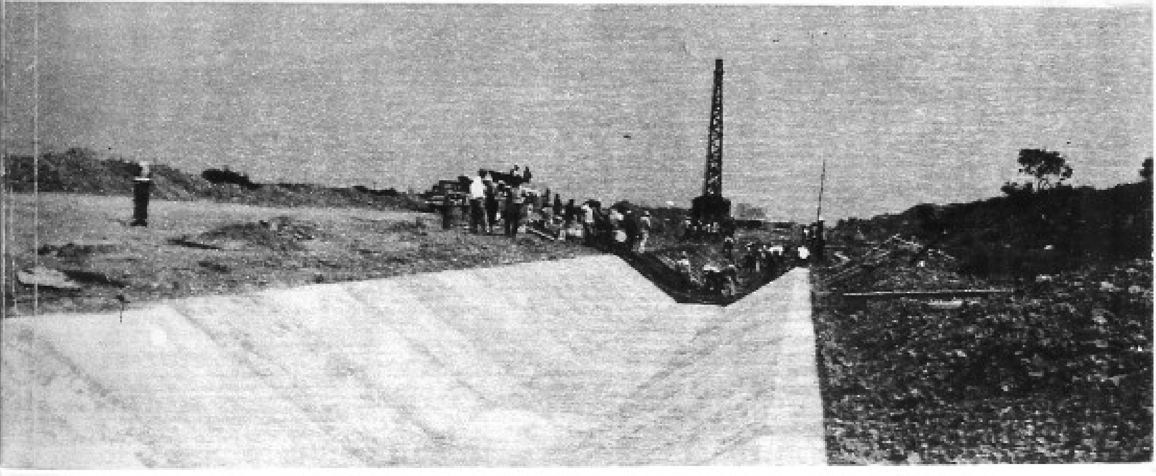
JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 22, 1968





JOURNAL
OF THE
RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 22, 1968

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

COVER: Mexico expects to have the Murillo Drain Project completed and in operation by the end of March 1969. This project, *which is being executed by the Mexican Section of the International Boundary and Water Commission* entirely within Mexico, heads at the Murillo Drain near its present mouth opposite the Bentsen State Park southwest of Mission and extends eastward through the City of Reynosa, past the community of Rio Bravo for a total distance of 39 kilometers where it will discharge into the existing drainage system leading into the Gulf of Mexico. The new channel, which will convey the highly saline waters of the Murillo Drain, will be concrete-lined between Anzalduas Dam and Reynosa. The flow will be carried through Reynosa in a reinforced concrete, underground conduit seven feet in diameter. Downstream from Reynosa the greater part of the channel is earthen ditch where the material encountered does not require lining. Cost of the project is borne *equally* by the United States and Mexico, *in keeping with the interest of both countries in preserving, as far as practicable, the beneficial value of the waters of the Rio Grande.* Valley interests have contributed one-half of the United States share of cost. Total project cost is $1,380,000.

When completed this project will decrease the total salt deposition to United States farms by 300,000 tons per year. Practically all of the Murillo Drain flow will be discharged directly into the Gulf of Mexico and as a result salt concentrations of the Rio Grande at Anzalduas Dam will rarely reach 1000 parts per million. A pumping plant will divert the flow into the new channel.

Top photo: Murillo Drainage Conveyance Channel. Looking up completed ditch near Kilometer 38.

Bottom photo: Murillo drainage conveyance channel. Concrete lining in progress at Kilometer 9, one mile below Anzalduas Dam.

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

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

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

Officers of the Rio Grande Valley Horticultural Society 1968

RICHARD HENSZ
President

PRESIDENT:
Richard Hensz

VICE PRESIDENTS:

Citrus	Gilbert Ellis
Vegetables	Orval Stites
Ornamentals	Ray Goodwin
Special Fruits	Arthur Hensz

SECRETARY:
Norman Maxwell

TREASURER:
Dr. John Fucik

NEWSLETTER EDITOR:
Bailey Sleeth

DIRECTORS

Citrus	Calvin Lyons
Vegetables	Connor Davis
Ornamentals	Milton Cash
Special Fruits	Jose Amador
At Large	Jim Kimbrel

INSTITUTE PROGRAM COMMITTEE

Dr. Bailey Sleeth, Chairman

SPECIAL ASSIGNMENTS

Editorial Committee: Tom D. Longbrake, Chairman
Publicity Committee: Harry Foehner

Table of Contents

Program of the Twenty-second Annual Institute of the Society January 23, 1968

MORNING PROGRAM

Mr. A. H. Karcher, Jr., Chairman

Address of Welcome .... Mr. Clay Everhard II, President
Rio Grande Valley Horticultural Society

Foreign Markets for
Valley Citrus and Vegetables .... Mr. M. F. Frost, Vice-President
Texas State Farm Bureau

Application of Cryogenic Principles
to Horticulture .... Mr. William Rockwood, Cryogenic Branch
Union Carbide Co., Brownsville, Texas

Systems Approach to Mechanical Harvesting
of Vegetables with Emphasis
on Processing Tomatoes .... Dr. William S. Sims
Extension Crops Specialist
University of California, Davis, California

Application of Remote Sensing
to Valley Agriculture .... Mr. Victor I. Myers
Soil & Water Conservation
Research Div., USDA, Weslaco, Texas

Presentation
of the Arthur Potts Award .... Mr. Clay Everhard II, President
Rio Grande Valley Horticultural Society

AFTERNOON PROGRAM

Mr. Gene Goodwin, Chairman

Trends in Entomology Research Toward Insect Population Suppression .... Dr. E. A. Taylor, Asst. Chief
Fruit & Vegetable Insects Research Branch
USDA, Beltsville, Maryland

Control of the Mexican Fruit Fly
by Sterilization .... Mr. L. F. Curl, Regional Supervisor
Plant Pest Control Div. Mexico Region
USDA, Monterrey, N. L., Mexico

Climate and Crops .... Dr. John Griffiths, Assoc. Prof.
Dept. of Meteorology
Texas A&M University, College Station, Texas

Microbial Control of Insects .... Dr. Howard Bullock, Pathologist
Entomology Res. Div., USDA
Entomology Research Center, Brownsville, Texas

EVENING PROGRAM

Dr. Joe B. Corns, Chairman

Safari in East Africa –
with colored slides .... Dr. John Griffiths, Dept. of Meteorology
Texas A&M University, College Station, Texas

Safari in Your Own Backyard –
colored film .... Mr. Norman Flitters, Entomology Res. Div.,
USDA Entomology Research Center
Brownsville, Texas

DR. P. W. ROHRBAUGH

Recipient of the Arthur T. Potts Award 1968

An award is presented to one person each year by the Rio Grande Valley Horticultural Society in recognition for outstanding work in horticulture. The award was named after its first recipient, Arthur T. Potts. Besides Mr. Potts the list of recipients includes Dr. Wilson Pompenoe, E. M. Goodwin, Dr. J. B. Webb, Dr. G. H. Godfrey, Dr. W. C. Cooper, Lon C. Hill, W. H. "Bill" Friend, Paul W. Leeper, Stanley B. Crockett, Harry Foehner, Sam D. Tayloe and O. F. Marrs.

The 1968 Arthur T. Potts Award was presented posthumously to Dr. P. W. Rohrbaugh. During his 15 years as Director of the Texas A&I University Citrus Center he was an active contributor to the progress of the Texas citrus industry. He brought a vast background in citrus when he came to the Valley from California in 1948. There he had served on the staff of the University of California Citrus Experiment Station and as head of the department of citriculture at California State Polytechnical College. He had also worked in the research department of Sunkist Growers.

Not only was Dr. Rohrbaugh an able administrator, he built a staff that has carried on admirably following his death, but he did much to help individual growers with their problems. Many growers gratefully acknowledge that his personal visits to their orchards and his advice were a great help to them.

He was instrumental in the initiation of considerable research into frost protection, nucellar citrus trees, herbicide use, and many other areas of citrus culture and management.

Many also knew him as one of the instructors in the citriculture and other classes that were taught at the Citrus Center. These courses have been taken by hundreds of people, many of whom were more interested in improving their knowledge of citrus and orchard management rather than the college credits that went with them.

Dr. Rohrbaugh was a native of Jefferson County, Nebraska. He received his A.B. degree from Nebraska Wesleyan University, an M.S. degree from Iowa State College, and his doctorate from U.C.L.A.

ADDRESS OF WELCOME

22nd Annual Horticultural Society Institute

On behalf of the Rio Grande Valley Horticultural Society, I want to open this twenty-second annual Institute with a warm and hearty welcome to you all. May this day be rich in rewards for those who have come here to gain knowledge, for those who have come here to share their knowledge, and for those who have worked so hard to make this meeting possible.

There is an old addage which says, "The only thing permanent is change." It applies very well to this Society and to the audience which has attended these meetings since they began in 1946. Even this annual meeting itself, when held for the first time, took three days to present. But more significant changes in our weather and markets were not far away.

Although the Horticultural Society bears none of the guilt, since the time it was formed our Valley has been hit by some disastrous changes in the weather. We had record-setting freezes in 1951 and 1962 with a devastating drouth in-between. And then four months ago our lives were all changed in some way or another by a direct hit from Beulah. The damage to our homes, our crops, and our lands by the wind and waters resulting from that encounter is still being counted today.

Since 1946 we have seen the agricultural marketplace change from a seller's market to a buyer's market—with corresponding pressure on the price of farm products. Most of the per-ton prices for Valley crops fluctuate today in about the same range of dollars they did twenty years ago—certainly not much higher, and we're using a much less valuable dollar these days. At the same time industrial wage and material costs have tripled the price of much of the equipment the farmer must buy.

We once had an advantage with our inexpensive and plentiful labor supply here near the Rio Grande. But over the past twenty years the farm vote has not been so strong, and the wishes and votes of organized labor have become more important to our government. From around 30c per hour in 1946, our field hands have been raised in pay, first by the Bracero Program, and more recently by the federal minimum wage. Next week we will be paying $1.15 per hour.

Obviously, with all this pressure on his profits, the grower has had to make some changes in his operation over the past twenty-two years. If he can't get more dollars per ton, then he has had to get more tons per acre. If his labor and equipment cost more, then he has had to make them do more. These changes have meant that he has had to adopt new techniques in order to accomplish these goals. Guidance for these changing methods is provided by the many research facilities right here in our Valley.

If I have made the government seem like the villain in this melodrama because of its help in raising farm costs, it is because the other side of the story has not yet been told. Because of the concern of our governments for the farmer, help and advice is available to the grower from an army of competent experts who spend their lives dealing with horticultural problems. Millions of dollars have been spent by the federal and state governments on research facilities in the Valley to help improve the growers' techniques. From another government agency cash assistance is available to help level land, install irrigation lines, drainage structures, and to make many other conservation practices less expensive to the land owner. So, our government does help us a great deal by supplying guidance and financial assistance.

A very subtle but important distinction must be made at this point. The grower has had no control over the changes which have upset his weather patterns, his markets, and his political influence. These changes have been forced upon him. But no one forces him to improve his practices—these ways of improving his livelihood are only available to him, and he must come and get them for himself. Thus only the grower who regularly seeks help and information can expect to make the most from his enterprise in these times.

It is this regular association that is our stock-in-trade in this Horticultural Society. Our meetings are a forum for solutions to problems which growers face and a sounding board for new problems which arise. Twenty-two years ago this society was limited to only 45 members, but this too changed. Over the years our individual membership has grown to several hundred persons who are not only technical people, but growers, hobbyists, and other interested people from all sorts of diverse backgrounds. We also enjoy the support of many Valley business firms who purchase contributing memberships and provide most of the funds for publishing our JOURNAL and underwriting our other activities—which include this Institute.

Although the membership has changed through the years, the aims of the Society have not. As before, we join together in the face of adversity to help solve each other's problems. I regret to have to report to you that even after all this effort by all these people for all these years, all of the problems have not been solved. Your presence today indicates an interest in keeping up with the changes which are being made to cope with today's problems in horticulture. The program today deals with some of the approaches we are using in this "Space Age." Many of the subjects you will hear discussed today were not dreamed of twenty-two years ago. But times have changed, haven't they?

I want to publicly thank Dr. Joe Corns, our program committee chairman for all his efforts to present today's outstanding program. He was helped a great deal by three other fine Ph. D.'s on his committee:

Dr. Norman Flitters, Dr. Bailey Sleeth, and Dr. Dick Hensz.

We should also thank Dr. Hensz and the staff and administration of A&I for letting us use these buildings for our meeting today and for our monthly meetings during the year.

The emcees and speakers who follow are the stars of our show today. They have taken time out of their busy schedules, and some have traveled great distances to be here today. Thanks for coming, and I hope you enjoy the program.

CLAY EVERHARD II, *President*

CITRUS

Preliminary Evaluation of a Semi-Permanent Irrigation System for Citrus

C. J. Gerard[1], A. V. Shull[2], B. Sleeth[1], and S. D. Tayloe[2]

Abstract: A "hose pull" irrigation system is described. Cost estimates for this and a larger installation are given. The efficiency of this low pressure sprinkler irrigation system is undoubtedly much higher than any of the present systems that would apply the same amount of water in less time. Studies conducted using the described system indicate that rapid increase in fruit growth during the hot summer months occurred only under high soil moisture conditions. Soil compaction decreased deep root activity, moisture use and moisture penetration in certain parts of the grove.

The decreasing labor force and limitations in the irrigation water supply pose problems of critical significance to the entire agricultural economy of the Lower Rio Grande Valley of Texas. These problems are of particular concern to the citrus industry in which both the adequacy and timing of irrigation are critical factors of production. With the currently used practices of basin flooding and sprinkler irrigation, citrus growers are confronted with the problems of inadequate labor and inefficiency in the utilization of limited water supplies to the extent that profitable fruit production is in serious jeopardy. Hilgeman et al (1959) and Lombard et al (1965) have shown that fruit enlargement and yield are related to moisture stress and evaporative conditions or other factors which influence moisture stress and evaporative conditions.

The installation of permanent or semi-permanent facilities to reduce manpower requirements and to achieve maximum efficiency in the use of irrigation water has been limited because of the high initial investment required. Although initial costs are still problems of major concern, growers are expressing an increased interest in more permanent operative systems which operate efficiently and effectively reduce labor requirements.

A semi-permanent system recently observed in California is operative and appears to be economically feasible under production conditions in that State. This system was recently described by Zall (1967). A preliminary study was initiated in 1966 to evaluate the practicality, efficiency and economic feasibility of a similar system of irrigation under South Texas conditions.

---

[1] Respectively, Associate Professor and Professor Emeritus, Texas Agricultural Experiment Station, Lower Rio Grande Valley Research and Extension Center, Weslaco.

[2] Respectively, Citrus Manager and General Manager, Rio Farms, Inc., Edcouch.

PROCEDURE

A "hose pull" experimental irrigation system was installed on a 2.5 acre citrus orchard at Rio Farms near Monte Alto, Texas. Underground polyvinylchloride (PVC) pipes 1 to 1½ inch in diameter were installed throughout the grove. Hydrants were positioned at regular intervals in the grove. The distribution hose was ⅝ inch plastic tubing. All sprinklers were equipped with tips to apply 2.65 acre inches of water in 12 hours. The water is ejected from the sprinkler at a low trajectory so as to deliver water under the tree canopies. A photograph of the sprinkler system in operation is shown in Fig. 1. A 1¼ inch Marlow centrifugal pump was used to maintain a uniform pressure of 30 psi at the sprinkler outlets.

Soil moisture stress at different times during the growing season were determined at soil depths of 12, 24 and 36 inches with vacuum gauge tensiometers. Soil moisture use at different depths was determined using neutron scattering technique. Increase in fruit circumferences during the growing season was determined at regular intervals.

Moisture retention characteristics, soil salinity and bulk density in different parts of the grove near moisture measuring sites were de-

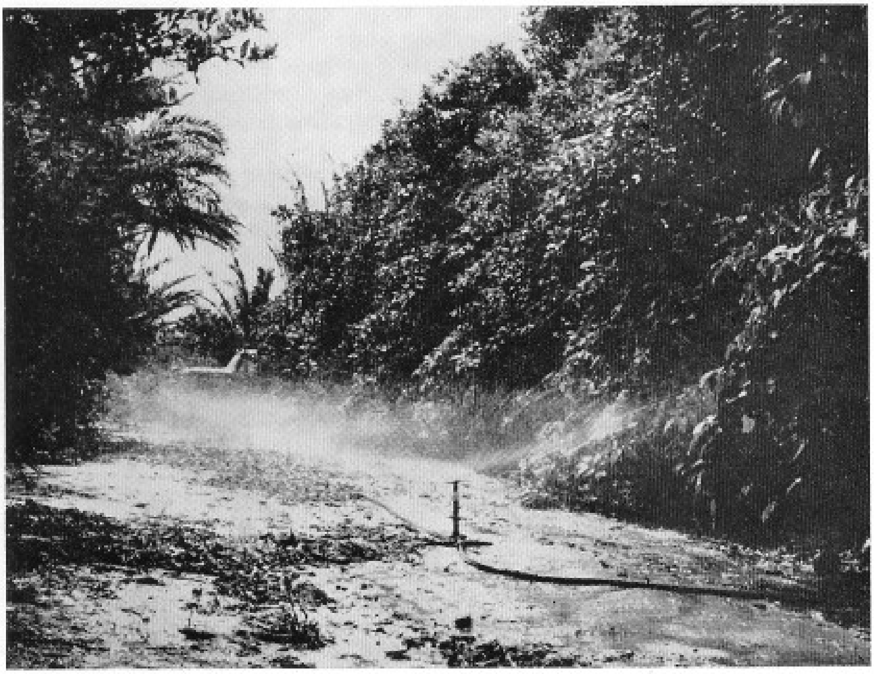


Figure 1. Sprinkler system in operation.

termined by conventional methods. Penetrability of soil was evaluated with a penetrometer at each of the sites. Distribution of tree roots was also evaluated at each location.

RESULTS AND DISCUSSION

The low pressure sprinkler irrigation system was effective in applying water with very little loss from surface runoff. The efficiency is higher than any of the present systems that would apply the same amount of water in less time. One of the chief advantages of the present system is that it can be adjusted to apply water at the rate of water intake by the soil thus preventing loss from runoff. When and if water was metered, this system would permit applying just enough water to replenish the available water in the primary root zone. However, from time to time it will be necessary to apply enough water to leach the profile of accumulated salts.

The estimated cost for installation, maintenance, irrigation, spraying, labor and depreciation for the 2.5 acre plot and a 40 acre grove are presented in Table 1. This system cost $437.10 per acre to install, which is probably $50 to $75 per acre more than it would cost to make an installation in a larger block. In this case, the depreciation figure per acre would be about $24.50. This figure excludes depreciation on the pump since in a larger installation, a diesel-powered pump would be utilized.

This layout also involves very inefficient pumping. During the past 12 months, the plots were irrigated 9 times at a 2½ to 3-acre inch rate at a cost of $29.47 per acre foot. By contrast, the average hourly operating cost of operating a diesel powered pump in a producing grove was

Table 1. Cost estimate for maintenance, irrigation, spraying, labor and depreciation of drag-hose irrigation system.

	*Cost Per Acre 2.5 acre experimental grove**	*Estimated Cost Per Acre 40 acre grove***
Chemical weed control	$ 34.80	$ 34.80
Irrigation	20.60	16.70
Power, electric 2.5 acre; diesel 40 acre	66.36	13.50***
Spraying	18.72	18.72
Other Labor	1.60	6.00
Total	142.08	89.72
Depreciation on System	36.69	24.50
Total Cost	178.77	114.22
Initial Cost for System	437.10	387.10

* Cost for operation of 2.5 acre grove.
** Estimated cost for operation of a 40 acre grove.
*** Diesel power.

$0.83 per hour. This pump delivers 1000 gpm at 70 psi and would pump an acre foot of water in about 5½ hours at a cost of approximately $4.57. On a 40-acre unit, which would only use ½ of the capacity of the diesel pump, the pumping cost for the 10-acre feet required for an irrigation would be about $59.76 or about $6 per acre foot.

An additional and important saving is in the cost of irrigating. The average orchard on Rio Farms was irrigated 4 times in the past 12 months. If flooded, an estimated 2-acre feet of water was used costing $8, and 17 hours of labor were required costing approximately $17 or a total of $25 per acre for water and labor.

With the drag-hose system, nine 2½ to 3-inch irrigations were applied using about 2¼ acre feet of water, costing $9. Eleven hours of labor were required, costing $11 or approximately $20 per acre for water and labor. This labor requirement of a little over one hour per acre can be reduced approximately 30% when utilized on a larger acreage.

It should be noted that the drag-hose system all but eliminates the use of heavy tools. No discing — no bordering — no ditching — no border checking — no roto-tilling are required. The only machines used in the orchard are sprayers for insect and weed control.

Soil moisture stress at different depths and times are shown in Fig. 2. Growth rate of fruit at different times during the growing season was a function of moisture stress. During June, July, August and September rapid increase in fruit growth was preceded by irrigation or rain (low moisture stress). These data suggest that to insure good fruit growth during the summer months growers must maintain high soil moisture conditions by frequent irrigations. Lombard et al (1965) reported similar trends in California. The use of the "hose pull" irrigation system would make it possible to apply more frequent light irrigations which appear to promote fruit growth during the summer. Further research is needed to more clearly define the relationship between fruit growth and soil moisture tension.

Soil moisture use shown in Table 2 varied from about 0.05 of an inch per day during the winter to over 0.3 inch per day during the summer. Soil moisture use at Site 1 was higher than at Site 2. Root distribution at the two sites shown in Table 3 indicate that trees at Site 1 had a deeper root system. The resistance to penetration of the soil as evaluated with a soil penetrometer indicated that soil at 3-15 inches at Site 2 was more difficult to penetrate than soil at Site 1. Penetrometer evaluations indicated the presence of a compacted layer at the 6-inch depth. Electrical conductivities of saturation extract of soil at different depths in 1966 indicated that the soil at Site 2 also had greater salt concentration at all depths as indicated in Table 4. This would suggest that this site was less permeable to water and therefore irrigations and rainfall were not as effective in leaching the salt at this site. However, electrical conductivities of saturation extract of soil in 1968 (Table 4)

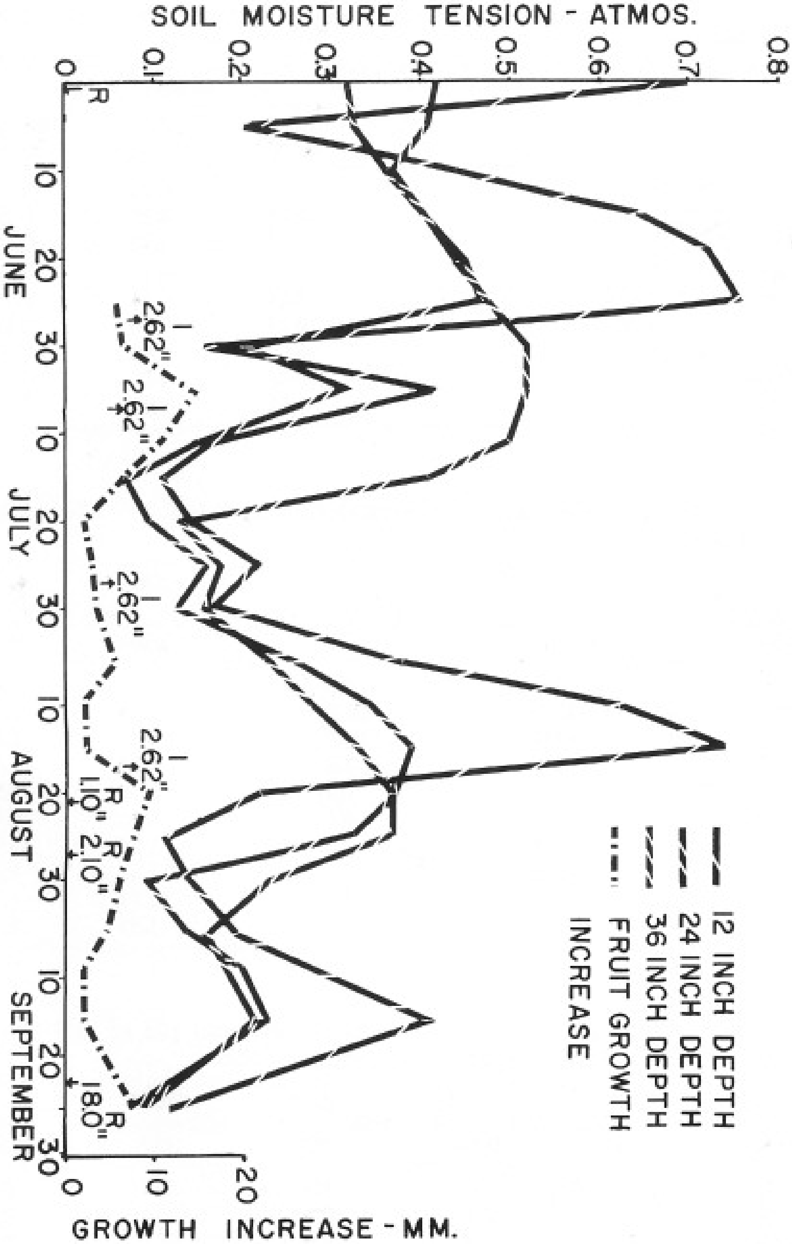


Figure 2. Soil mositure tension at different soil depths and increase in circumference of fruits from June through September, 1967. Irrigation amount and time are indicated as "I" and significant rains and amount by "R".

Table 2. Average moisture use at different times during growing season in 1967.

Time of measurement	Moisture Use		
	Site 1 in/day	Site 2 in/day	Average in/day
4/5/67 - 5/1/67	0.15	0.12	0.14
5/8/67 - 5/31/67	0.31	0.23	0.27
6/5/67 - 7/25/67	0.14	0.13	0.14
7/29/67 - 8/12/67	0.31	0.14	0.23
10/5/67 - 10/24/67	0.21	0.14	0.18
10/24/67 - 11/15/67	0.12	0.09	0.11
11/15/67 - 12/23/67	0.03	0.06	0.05
12/23/67 - 2/2/68	0.08	0.05	0.07
2/2/68 - 3/4/68	0.05	0.03	0.04

Table 3. Root distribution at different depths at outskirt of tree canopy at Site 1 and Site 2.

Soil depth inches	Site 1 Root activity %	Site 2 Root activity %	Site 1 Bulk density	Site 2 Bulk density
			gm/cc	gm/cc
0-3	0.6	1.8	—	—
3-9	15.3	55.4	1.58	1.54
9-15	62.6	19.7	1.55	1.50
15-21	8.4	7.6	1.52	1.49
21-27	4.1	7.5	1.59	1.57
27-33	4.6	6.1	1.61	1.49
33-39	3.2	1.9	1.54	1.56
39-45	1.2	0	1.45	1.52
45-51	0	0	1.71	1.57
51-57	0	0	1.84	1.56

Table 4. Average conductivity (millimhos/cm) and pH of soil at different depths of Site 1 and Site 2 in 1966 and 1968.

Soil depth ft.	Site 1 millimhos/cm 1966	Site 2 millimhos/cm 1966	Site 1 millimhos/cm 1968	Site 2 millimhos/cm 1968	pH 1968
0-1	1.0	—	1.0	1.0	6.6
1-2	0.5	2.8	2.1	2.3	7.3
2-3	1.4	3.4	1.9	1.7	7.8
3-4	2.0	4.0	2.1	2.1	8.0
4-5	2.5	4.2	—	2.1	7.9

indicated that the sprinkler system and/or heavy rainfall during and following Hurricane Beulah effectively reduced the salt concentrations at all depths.

The "hose pull" irrigation system should help to replenish uniformly the water of the effective root systems on unlevel sites or sites which have compacted zones in certain parts of the grove. The outstanding advantage of the "hose pull" system is that the water application rate can be adjusted to the water intake capacity of the soil.

LITERATURE CITED

1. Lombard, P. B., L. H. Stolzy, M. J. Garber and T. E. Szuszkiewicz. 1965. Effects of climatic factors on fruit volume increase and leaf water deficit of citrus in relation to soil suction. Soil Sci. Soc. Amer. Proc. 29:205-208.
2. Hilgeman, R. H., H. Tucker and T. A. Hales. 1959. The effect of temperature, precipitation, blossom date and yield upon the enlargement of Valencia oranges. Proc. Amer. Soc. Hort. Sci. 74:266-279.
3. Zall, T. 1967. The semi-portable "hose pull" irrigation system, etc. Amer. Fruit Grower. p. 6 and 55.

Freeze Injury to Young Fairchild and Bower Tangerine Trees on Six Rootstocks in the Winter Garden Area

NORMAN P. MAXWELL[1] and HEINZ K. WUTSCHER[2]

The Winter Garden area of Texas, centered around Crystal City, produces early maturing oranges and tangerines with excellent interior quality and highly colored peels. The citrus industry of this region and the Rio Grande Valley suffered extensive freeze damage in 1951 and 1962.

Rootstocks influence the cold hardiness of citrus. In order to determine the best rootstock for tangerines in the Winter Garden area a test was started in April 1966 as a cooperative experiment between the Texas Agricultural Experiment Station and the Crops Research Division of the U. S. Department of Agriculture.

MATERIALS AND METHODS

Two clones of tangerines, Fairchild and Bower (*C. reticulata* Blanco x (*C. paradici* MacF. x *C. reticulata*), were planted in 2 rootstock tests on the Rio Grande Plains Research and Demonstration Station. The test plots consisted of 10 single-tree replications with 6 different rootstocks. On either side of the test Marrs oranges were planted in solid rows as pollinators.

The rootstocks used in the test were sour orange (*C. aurantium* L.), *Citrus intermedia* (Hort. ex Tanaka) Changsha mandarin (*C. reticulata*), Morton citrange (*Poncirus trifoliata* x *C. sinensis* Osbeck), Sun Chu Sha Kat mandarin (*C. reticulata*) and Cleopatra mandarin (*C. reticulata*). In the Fairchild test there were only three trees on *Citrus intermedia*, and the Bower test included only nine replications of Bower on Sun Chu Sha Kat and Cleopatra mandarins.

The test plots were located on bench levelled sandy loam land having excellent air drainage. The trees received normal grove care, including irrigation. In November 1966 they were banked with soil for cold protection.

Freezes occurred in the Crystal City area on the nights of December 11, 12, 13 and 14, 1966. Temperature data for the freeze nights

[1] Assistant Professor, Texas Agricultural Experiment Station, Weslaco, Texas.

[2] Research Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas.

recorded at the Rio Grande Plains Research-Demonstration Station are presented in Table 1. The coldest temperatures occurred on December 12 and 13 during clear, still, radiant freeze nights.

In April 1967 a freeze damage reading was made on the test trees. A scale of 1 to 5 was used in determining the degree of injury: 1 was partial defoliation, 2 was defoliation with no wood damage, 3 was defoliation and small twigs killed, 4 was defoliation and twigs killed to ½ inch wood, and 5 was trees killed to the soil bank. The same scale of 1 to 5 was used in reporting cold damage to several citrus varieties in the December 1966 freeze at Crystal City (1).

RESULTS

The data on cold damage taken in April 1967 are given in Tables 2 and 3. Fairchild tangerine exhibited about the same degree of hardiness on mandarin and Morton citrange rootstocks. On sour orange, Fairchild was somewhat less hardy, while the tenderest trees were those on *Citrus intermedia.*

Cold damage to the Bower tangerine tops varied little on the different rootstocks, with the exception of the trees on *Citrus intermedia,* where damage was also severe. More of these trees were killed to the soil bank than on the other rootstocks.

Fairchild scions were more cold-hardy than Bower scions. This agrees with data reported elsewhere (1) on injury by the same freeze to trees in a variety test block at the Rio Grande Plains Research-Demonstration Station.

The minimum night temperatures 10 days to 2 weeks before a freeze will influence tree dormancy (2, 3). Table 4 gives the maximum, minimum and mean temperatures recorded during the 2 weeks before the 1966 freeze. These temperatures were not as low as those common in this area later in the season, but they were low enough to stop tree growth and induce dormancy which made the trees more cold hardy.

CONCLUSIONS

The relative cold hardiness of the scions as influenced by the rootstocks varied only slightly in both the Fairchild and the Bower test. Citrus intermedia appeared to make the scions more tender than the other rootstocks. Trees on sour orange were about as hardy as those on Morton citrange and mandarin rootstocks when Bower was the scion, but Fairchild scions on sour orange were less cold hardy.

Although Fairchild tangerine withstood the freezing temperatures of December 1966 somewhat better than Bower tangerine, both varieties, when grown on appropriate rootstocks, appear to be well suited for the

Table 1. Temperatures recorded at Rio Grande Plains Research and Demonstration Station during freeze of Dec. 11-14, 1966.

	Degrees Farenheit										
	10:00 P.M.	*11:00 P.M.*	*12:00 M*	*1:00 A.M.*	*2:00 A.M.*	*3:00 A.M.*	*4:00 A.M.*	*5:00 A.M.*	*6:00 A.M.*	*7:00 A.M.*	*8:00 A.M.*
Dec. 11, 1966	36	34	32	30	28	27	26	26	25	25	25
Dec. 12, 1966	32	30	28	27	26	25	24	23	24	23	24
Dec. 13, 1966	40	36	32	30	28	28	28	26	25	23	23
Dec. 14, 1966	40	39	38	34	32	28	28	28	27	26	26

Winter Garden area. Periods of low temperatures before a freeze apparently harden the trees. Similar freezes in the Rio Grande Valley where night temperatures are generally higher would probably cause more severe damage.

Table 2. Amount of cold damage in the Fairchild tangerine rootstock test during the freeze of Dec. 11-14, 1966, at the Rio Grande Plains Research and Demonstration Station.

	Degree of Damage					*No. trees*
Rootstock	*1*	*2*	*3*	*4*	*5*	*Evaluated*
Sour orange	0	6	2	0	2	10
Citrus intermedia	0	1	0	0	2	3
Changsha mandarin	0	5	5	0	0	10
Morton citrange	0	8	2	0	0	10
Sun Chu Sha Kat mandarin	0	8	2	0	0	10
Cleopatra mandarin	0	6	4	0	0	10

[1] Partial defoliation
[2] Defoliation, no wood damage
[3] Defoliation, small twigs killed
[4] Defoliation, twigs killed to one half inch wood
[5] Tree killed to soil bank

Table 3. Amount of cold damage in the Bower tangerine rootstock test during the freeze of Dec. 11-14, 1966 at the Rio Grande Plains Research and Demonstration Station.

	Degree of Damage					*No. trees*
Rootstock	*1*	*2*	*3*	*4*	*5*	*Evaluated*
Sour orange	0	1	7	1	1	10
Citrus intermedia	0	3	3	--	4	10
Changsha mandarin	0	2	6	--	2	10
Morton citrange	0	3	5	--	2	10
Sun Chu Sha Kat Mandarin	0	3	4	--	2	9
Cleopatra mandarin	0	3	3	--	3	9

[1] Partial defoliation
[2] Defoliation, no wood damage
[3] Defoliation, small twigs killed
[4] Defoliation, twigs killed to one half inch wood
[5] Tree killed to soil bank

Table 4. Temperatures for two weeks prior to the December 11-14, 1966 freeze at the Rio Grande Plains Research and Demonstration Station, Crystal City, Texas.

	Degrees Farenheit													
	November				*December*									
	27	*28*	*29*	*30*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Maximum	72.0	67.0	71.0	73.0	73.0	80.0	66.0	76.0	79.0	83.0	87.0	86.0	75.0	55.0
Minimum	51.0	35.0	31.0	39.0	48.0	47.0	57.0	51.0	54.0	58.0	56.0	61.0	43.0	38.0
Mean	61.5	51.0	51.0	56.0	60.5	63.5	61.5	63.5	66.5	70.5	70.5	73.5	59.0	46.5

REFERENCES

1. Maxwell, N. P. 1967. Cold Tolerance of Several Citrus Varieties and Strains on Sour Orange Rootstock During a Freeze in December 1966 at Crystal City, Texas. Jour. Rio Grande Valley Hort. Soc. 21: 68-73.

2. Cooper, W. C., Sam Tayloe and Norman Maxwell. 1955. Preliminary Studies on Cold Hardiness in Citrus as Related to Cambial Activity and Bud Growth. Jour. Rio Grande Valley Hort. Soc. 9: 1-15.

3. Young, Roger A. and A. Peynado. 1961. Seasonal Changes in the Cold-hardiness of Ten-Year-Old Red Blush Grapefruit Trees as Related to Dormancy and Temperature. Jour. Rio Grande Valley Hort. Soc. 15: 59-67.

Comparative Performance of Juvenile and Old-Line Redblush Grapefruit[1]

ROGER YOUNG, E. O. OLSON, and ART SHULL[2]

Abstract: Nucellar and old-line 'Redblush' grapefruit trees, grown on 11 rootstocks from 1956 to 1968, were larger than old-line trees and produced fruit of quality equal to those on old-line trees. Nucellar trees remained relatively juvenile and yielded less than old-line trees. The nucellar trees were propagated from young juvenile seedlings with no fruiting history; thus it was predictable that these nucellar trees would remain juvenile and produce a smaller crop of fruit. Stabilized clones of nucellar lines might, however, have performed better under the conditions of these studies.

INTRODUCTION

Orchard performance of xyloporosis- and exocortis-infected old-line Redblush grapefruit *(Citrus paradisi* Macf.*)* trees on 100 rootstocks has been evaluated for many factors (Cooper et al. 1956, 1957, 1957; Olson et al. 1962). One of the main factors governing the performance of a particular rootstock was its degree of susceptability to xyloporosis and exocortis viruses. Only a few rootstocks were found to be relatively tolerant to both viruses: sour orange, rough lemon, sweet orange, Cleopatra mandarin, several citranges, grapefruit, and shaddocks. Trees on rough lemon rootstock were reputedly short-lived, due to cold injury, and gave low quality fruit. The sweet oranges, as rootstocks, were sensitive to footrot caused by Phytophthora fungi, and the citranges were generally sensitive to saline irrigation water. Thus, only sour oranges and a mandarin emerged as practical rootstocks for these virus-infected scions.

For proper evaluation of many of these rootstocks with and without viruses, comparison of the growth and production of virus-free nucellar trees and infected trees was deemed necessary. This report summarizes the performance of these trees over a 12-year period.

METHODS AND MATERIALS

The rootstock planting was located at Rio Farms, Monte Alto, and the trees were planted in 1956. Trees on each rootstock were set in four replicates of three-tree blocks, each replicate consisting of three

[1] The work is part of a cooperative project of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, the Texas Agriculture Experiment Station, Weslaco, Texas, and Rio Farms, Inc., Monte Alto, Texas.

[2] Plant Physiologist and Plant Pathologist, Crops Research Devision, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas, and Indio, California, and Manager, Citrus Dept., Rio Farms, Inc., Monte Alto, Texas, respectively.

old-line trees and three nucellar trees. The budwood source tree for the propagation of old-line trees was a productive old-line Redblush tree at Hoblitzelle Ranch. The budwood source trees for propagation of nucellar trees were three, 4-year-old Rio Farms seedlings which had not yet fruited. The bud-source trees were indexed and the old-line tree was found to be a symtomless carrier of xyloporosis and exocortis viruses, while the three nucellar trees were free of viruses.

The test trees were propagated on 11 rootstocks. Rootstock varieties were sour orange, *C. aurantium* (L) Osbeck, *C. taiwanica* Tan. and Shim., 'rough' lemon, *C. limon* (L.) Burn., 'Dancy' tangerine; 'Cleopatra' mandarin; and 'Sunki' mandarin, *C. reticulata* Blanco, 'Carrizo' citrange [*P. trifoliata* (L.) Raf. x *C. sinensis* (L.) Osbeck], 'Suenkat' mandarin, *C. reticulata* Blanco, 'Columbian' sweet lime, *C. limettoides* Tan., 'Sunshine' tangelo, ('Duncan' grapefruit *C. paradisis* Macf. x 'Dancy' tangerine *C. reticulata* Blanco), and 'Rangpur' lime, *C. reticulata* var. Austera Swing. (hybrid).

The soil in the Rio Farms orchard was Brennan fine sandy loam and noncalcareous. The grove was kept weed-free, and it was flood-irrigated when necessary.

Trunk diameters, 6 inches above the bud union, were calipered in 1958 and 1968. Tree height in 1957 and 1967 and width in 1967 were measured with a calibrated pole.

Yields were recorded as the number of 70-lb boxes of fruit produced annually per tree. Fruit analyses from samples in December 1961, and January 1967, included the measurement of fruit diameter (cm), rind thickness (mm), rind color, and juice content. Rind color was determined by comparison with color plates published by Harding and Fisher (1945). The color of each fruit was measured by assigning to each color a numerical value, the greater value indicating a higher degree of yellow color.

The juice was extracted and composited from all the fruit in each sample, and the volume of juice, weight of juice, degree brix, and titratable acidity were determined. Degree brix was determined with a hand refractometer. Titratable acidity was determined by titrating a sample of juice to pH 8.2 with standard NaOH.

RESULTS

Tree growth. Nucellar trees grew larger and more rapidly than the old-line trees and were more juvenile as evidenced by their thorniness. In 1958 after 2 years of growth, trunk diameters of the nucellar trees were similar, although trees on Sunshine tangelo, Rangpur lime, and Columbian sweet lime were the largest (Table 1). Virus-infected old-line tree trunks were smaller than virus-free nucellar trees, with the largest differences occurring on Carrizo citrange (exocortis-sensitive), Columbian sweet lime (xyloporosis-sensitive), and Rangpur lime (xyloporosis-sensitive). In 1968, nucellar trees had trunk diameters which ranged from 10.8 to 12.6 inches with largest trunks on Carrizo citrange rootstock. Trunk diameters of old-line trees were 0.7 to 5.3 inches in diameter less than those of nucellar trees; the largest differences occurred on trees on Carrizo citrange, Columbian sweet lime, and Rangpur lime rootstocks. Height and width of nucellar trees in 1967 were consistently greater than old-line trees, with the greatest differences

Table 1. Growth of nucellar and old-line Redblush grapefruit trees on eleven rootstocks.

Rootstock and Scion	*Trunk diameter (inches)*		*Tree height (feet)*		*Tree width (feet)*	*Height/ width*	*Scaffold limbs (no./tree)*
	1958	*1968*	*1957*	*1967*	*1967*	*1967*	*1967*
Sour orange:							
Nucellar	3.5	11.5	6.6	14.5	20.2	0.72	13.7
Old-line	3.3	9.6	5.4	11.2	16.7	0.67	10.1
Taiwanica:							
Nucellar	3.6	12.1	6.8	14.0	19.4	0.72	12.2
Old-line	3.3	10.4	6.0	10.6	15.5	0.68	9.2
Rough lemon:							
Nucellar	3.3	10.9	6.0	14.0	17.8	0.79	11.7
Old-line	3.1	9.4	5.9	10.2	11.2	0.91	7.1
Dancy:							
Nucellar	3.5	10.8	6.1	14.0	19.1	0.73	10.5
Old-line	3.0	9.6	5.3	12.2	17.1	0.71	7.5
Cleopatra:							
Nucellar	3.6	11.2	7.1	14.3	19.5	0.73	9.8
Old-line	3.2	9.7	5.8	11.0	15.3	0.72	8.7
Sunki:							
Nucellar	3.5	11.5	6.7	14.2	18.7	0.76	12.9
Old-line	3.1	9.2	5.4	10.5	15.0	0.70	11.6
Carrizo:							
Nucellar	3.7	12.6	6.6	14.1	19.5	0.72	13.6
Old-line	2.9	7.4	5.2	9.2	13.0	0.71	7.1
Suenkat:							
Nucellar	3.7	10.9	6.6	14.0	18.8	0.74	11.0
Old-line	3.1	10.2	5.7	11.7	16.8	0.70	10.0
Columbian:							
Nucellar	4.0	12.0	7.6	12.5	18.8	0.66	11.8
Old-line	2.7	6.7	5.9	9.0	12.0	0.75	5.5
Sunshine:							
Nucellar	3.8	11.5	6.8	14.1	20.0	0.70	13.6
Old-line	3.2	9.2	5.7	11.0	15.1	0.73	8.4
Rangpur:							
Nucellar	4.2	12.2	7.1	14.1	19.7	0.72	11.7
Old-line	3.2	6.9	6.4	8.2	11.8	0.69	7.3

occurring on Carrizo citrange, Columbian sweet lime, and Rangpur lime. Nucellar and old-line scions produced similarly shaped trees, their height to width ratio averaging 0.73. Nucellar trees on sour orange, the rootstock used industry-wide in Texas, were more than 3 feet taller and wider than old-line trees.

In 1967, the number of scaffold limbs per tree was greater on nucellar trees than old-line. Some of these were produced following the 1962 freeze. Fewest scaffolds per tree were on old-line trees on Rangpur lime, Columbian sweet lime, Carrizo citrange, and rough lemon.

Injury and recovery from 1962 freeze. In 1963, Young and Olson summarized the 1962 freeze injury of this planting. Freeze injury was very severe in most trees; wood 2 inches in diameter or larger was killed on many trees. Differences in prevention of wood injury induced by roostocks were great, although there were no differences between nucellar and old-line clones. Recovery of the trees since 1962 has varied greatly. In May 1962, when the first estimate of recovery was made, the nucellar trees appeared to make a much faster initial recovery than old-line trees. Poorest in recovery were old-line trees on Columbian sweet lime, Carrizo citrange, Rangpur lime, and Sunki mandarin.

In 1967, many trees had been removed because of poor recovery from the freeze. Fewest trees were lost with nucellar tops (Table 2). Freeze injury to the crotches and scaffold limbs was more severe on nucellar than old-line tops on sour orange, rough lemon, Dancy, Carrizo, and Columbian rootstocks. No differences in crotch and limb injury between nucellar and old-line tops were found in Taiwanica, Cleopatra, Sunki, and Sunshine. Old-line trees on Suenkat and Rangpur were more severely injured than on nucellar tops. Nucellar and old-line trees on rough lemon were cold-sensitive; 50 per cent of the trees were removed following the freeze.

Hurricane damage. The loss of scaffold limbs from Hurricane Beulah was in proportion to freeze injury. Following the freeze, nucellar trees grew many new scaffold limbs which were more subject to breakage from high winds. In general, the nucellar trees lost more limbs from wind breakage.

Fruit yield. The final measure of a citrus tree's adaptability is its ability to survive local hazards and produce a good crop of high quality fruit. Fruit yield of juvenile nucellar and old-line trees on 11 rootstocks for 9 fruiting years is shown in Table 3. Without exception, the old-line trees out-produced the nucellar trees. Smallest differences between nucellar and old-line trees were on Columbian sweet lime and Rangpur lime. Although viruses were a limiting factor in tree growth and recovery from freeze injury with old-line trees on Columbian, Carrizo, and Rangpur, these trees still produced more fruit than their juvenile nucellar counterparts. The nucellar trees on Sunshine and Suenkat were poorest in fruit production. Highest producing trees were old-line trees on Sunki, rough lemon, Sunshine, and sour orange.

The aggregate production of all nucellar and old-line trees in tons per acre (110 trees per acre) is shown in Figure 1. Nucellar trees were 1 to 2 years later in fruiting than old-line trees, and their production at the time of the 1962 freeze was considerably less than the old-line trees. Following the freeze, the old-line trees made a more rapid recovery and out-produced the nucellar trees.

Fruit quality. Fruit quality was evaluated in December 1961 and January 1967 (Tables 4 and 5). No consistent differences in fruit dia-

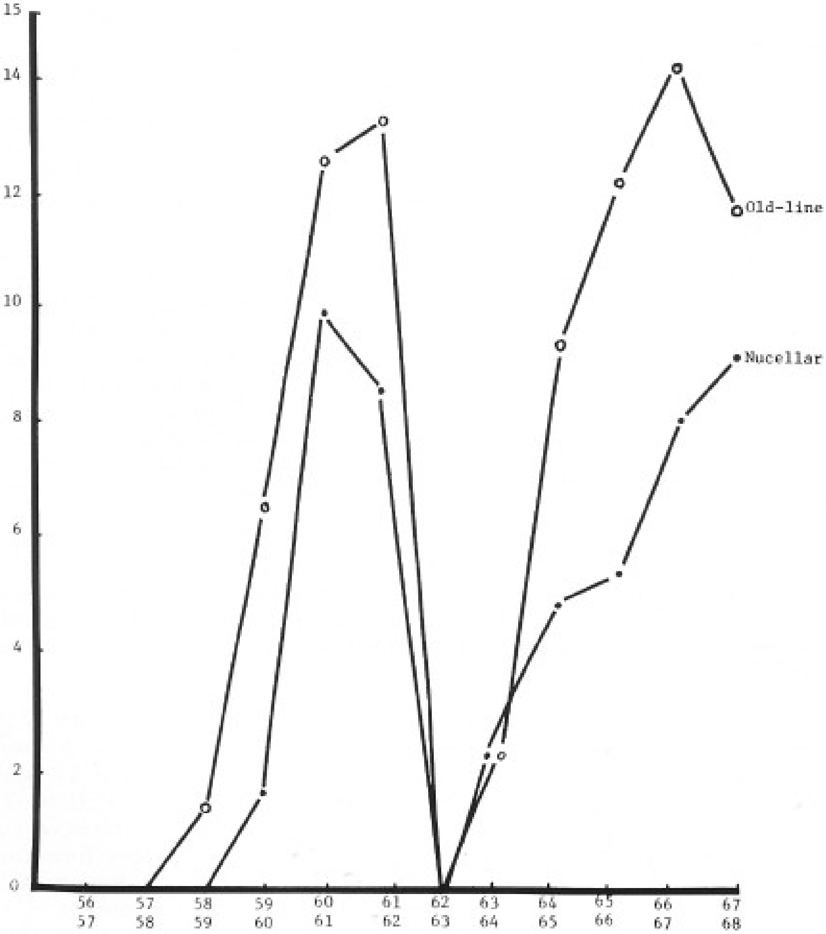


Figure 1. Yield of nucellar and old-line trees in tons per acre (110 trees/acre).

meter, rind thickness, rind color, juice percentage, acid, or brix/acid ratio were found between fruit on nucellar and old-line trees. Degree brix appeared slightly higher in the fruit from nucellar trees. Rootstock effects on fruit quality were slight, although fruit on trees on rough lemon, Taiwanica, and Columbian rootstock were lower in degree brix than on sour orange rootstock. Fruit on old-line trees on Carrizo,

Table 2. Recovery of nucellar and old-line Redblush grapefruit trees on eleven rootstocks from the 1962 freeze.

Rootstock and Scion	*No. trees planted*	*No. trees remaining in 1968*	*Injury from 1962 freeze* Crotch[a]	*No. scaffold limbs/tree*[b]	*Hurricane Beulah injury in 1967 No. scaffolds lost/tree*
Sour orange:					
Nucellar	12	12	1.5	2.3	0.6
Old-line	12	12	0.6	1.8	0.4
Taiwanica:					
Nucellar	12	11	1.2	2.8	0.5
Old-line	12	8	2.3	2.5	0.3
Rough lemon:					
Nucellar	12	5	0.9	2.8	0.7
Old-line	12	7	1.0	2.0	0.0
Dancy:					
Nucellar	12	9	0.3	1.8	0.8
Old-line	12	11	0.3	1.1	0.3
Cleopatra:					
Nucellar	12	12	0.3	1.0	0.5
Old-line	12	12	0.7	1.8	0.1
Sunki:					
Nucellar	12	12	1.1	2.7	1.1
Old-line	12	11	1.4	2.4	0.6
Carrizo:					
Nucellar	12	12	1.9	3.5	0.3
Old-line	12	8	1.4	0.9	0.1
Suenkat:					
Nucellar	12	12	0.3	1.8	0.3
Old-line	12	10	1.3	2.7	0.4
Columbian:					
Nucellar	12	10	1.7	3.7	0.7
Old-line	12	4	0.8	1.3	0.2
Sunshine:					
Nucellar	12	12	0.5	2.3	0.7
Old-line	12	12	1.7	2.3	0.2
Rangpur:					
Nucellar	12	12	1.2	1.3	0.3
Old-line	12	5	1.3	2.2	0.3

[a] 0 = none, 1 = slight, 2 = moderate, 3 = severe.
[b] No. of limbs with freeze cankers.

Columbian, and Rangpur rootstocks, affected severely by viruses, were not adversely affected in fruit quality.

Seasonal variations in fruit quality were greater than differences between scion varieties or among rootstocks. In January 1967, fruit had more juice and better rind color, but were less mature than fruit in December 1961. The 1967 fruit, although similar in degree brix, had higher acid contents, lower brix/acid ratios, and thicker peels than

Table 3. Fruit yield of nucellar and old-line Redblush grapefruit trees on eleven rootstocks.

Rootstock and Scion	*Yield*[a]		
	1958 - 1962	*1963 - 1968*	*Total*
Sour orange:			
Nucellar	5.3	8.4	13.7
Old-line	9.4	13.1	22.5
Taiwanica:			
Nucellar	5.2	5.9	11.1
Old-line	8.6	11.5	20.1
Rough lemon:			
Nucellar	5.3	6.7	12.0
Old-line	10.8	13.1	23.9
Dancy:			
Nucellar	3.3	9.7	13.0
Old-line	6.3	15.7	22.0
Cleopatra:			
Nucellar	4.2	10.5	14.7
Old-line	8.3	12.2	20.5
Sunki:			
Nucellar	4.2	8.3	12.7
Old-line	9.7	15.9	25.6
Carrizo:			
Nucellar	5.2	10.2	15.4
Old-line	9.1	13.2	22.3
Suenkat:			
Nucellar	4.7	6.1	10.8
Old-line	7.8	10.7	18.5
Columbian:			
Nucellar	8.9	5.3	14.2
Old-line	6.2	9.9	16.1
Sunshine:			
Nucellar	3.2	6.7	9.9
Old-line	10.0	13.6	23.6
Rangpur:			
Nucellar	8.9	9.7	18.6
Old-line	8.7	11.5	20.2

[a] 70-lb. field boxes/tree.

1961 fruit. This was true of fruit on both nucellar and old-line trees. The late maturing characteristics of these fruit were typical of fruit grown industry-wide in Texas.

DISCUSSION

Nucellar trees grew larger than old-line trees and produced fruit equal in quality to those on old-line trees. Nucellar trees, which had

Table 4. Characteristics of fruit from nucellar and old-line Redblush grapefruit trees on eleven rootstocks.

Rootstock and Scion	*Fruit diameter (cm)*		*Rind thickness (mm)*		*Rind color*[a]		*Juice (%)*	
	1961	*1967*	*1961*	*1967*	*1961*	*1967*	*1961*	*1967*
Sour orange:								
Nucellar	9.5	10.8	5.6	7.9	6.6	8.0	44	53
Old-line	9.7	9.9	5.8	7.1	6.3	7.6	45	53
Taiwanica:								
Nucellar	8.9	9.4	5.3	6.1	6.2	7.5	45	52
Old-line	9.2	9.7	5.4	6.6	6.1	7.0	43	51
Rough lemon:								
Nucellar	10.0	9.4	6.6	7.0	6.2	7.9	43	48
Old-line	9.7	9.4	5.8	7.0	6.0	7.4	44	51
Dancy:								
Nucellar	9.3	9.9	5.6	7.4	6.3	7.8	42	49
Old-line	9.3	9.5	5.5	6.9	6.1	7.4	43	50
Cleopatra:								
Nucellar	9.6	9.9	5.9	7.0	6.3	7.6	43	52
Old-line	9.1	9.3	5.1	6.3	6.0	7.5	45	53
Sunki:								
Nucellar	10.2	10.2	6.7	7.2	6.5	7.9	41	49
Old-line	9.7	10.5	5.7	7.7	6.1	7.4	43	49
Carrizo:								
Nucellar	9.3	9.8	5.4	6.9	6.2	7.4	43	51
Old-line	9.5	9.4	5.3	6.6	6.5	7.4	43	50
Suenkat:								
Nucellar	9.6	9.5	5.8	6.4	6.5	7.7	43	51
Old-line	9.1	9.3	5.1	6.3	6.1	7.1	44	53
Columbian:								
Nucellar	9.6	9.6	5.8	6.6	6.3	7.3	44	52
Old-line	9.5	10.6	5.6	7.4	6.4	6.7	45	50
Sunshine:								
Nucellar	9.5	10.2	5.8	7.4	6.5	7.9	43	51
Old-line	9.1	10.4	5.6	7.4	6.3	7.2	43	50
Rangpur:								
Nucellar	9.5	9.9	5.6	7.1	6.2	7.7	45	47
Old-line	9.6	9.7	5.5	6.9	6.2	7.5	45	53

[a] Color ratings taken from Harding's grapefruit color index.

cold hardiness equal to old-line trees in 1962, regrew tops faster after the freeze, and fewer trees were removed subsequent to the freeze because of poor recovery. However, the rapid growth before the freeze and regrowth subsequent to the freeze, coupled with the freeze injury to the crotches and scaffold limbs and limbs lost during Hurricane Beulah, all contributed to the nucellars remaining relatively vegetative. Consequently, yields remained only fair when compared to old-line tops. Although viruses were absent in the nucellar trees, no nucellar-rootstock

Table 5. Juice characteristics of fruit from nucellar and old-line Redblush grapefruit trees on eleven rootstocks.

Rootstock and Scion	*Brix (°)*		*Acid (%)*		*Brix/Acid*	
	1961	*1967*	*1961*	*1967*	*1961*	*1967*
Sour orange:						
Nucellar	10.9	11.2	1.22	1.45	9.0	7.7
Old-line	10.5	10.8	1.37	1.54	8.0	7.0
Taiwanica:						
Nucellar	10.2	10.0	1.24	1.30	8.2	7.7
Old-line	9.6	9.2	1.24	1.23	7.7	7.5
Rough lemon:						
Nucellar	10.1	11.1	1.17	1.47	8.6	7.6
Old-line	9.5	9.9	1.15	1.28	8.3	7.7
Dancy:						
Nucellar	11.4	11.6	1.37	1.56	8.3	7.4
Old-line	10.6	11.1	1.29	1.53	8.2	7.3
Cleopatra:						
Nucellar	10.5	10.9	1.23	1.42	8.5	7.7
Old-line	10.1	10.5	1.24	1.43	8.1	7.3
Sunki:						
Nucellar	10.8	11.2	1.30	1.46	8.3	7.7
Old-line	10.3	10.4	1.26	1.38	8.2	7.5
Carrizo:						
Nucellar	10.0	10.4	1.22	1.29	9.0	8.1
Old-line	10.9	11.0	1.22	1.40	8.6	7.9
Suenkat:						
Nucellar	10.7	10.8	1.30	1.43	8.2	7.6
Old-line	10.2	10.0	1.25	1.37	8.2	5.5
Columbian:						
Nucellar	10.2	9.9	1.19	1.27	8.6	7.8
Old-line	10.2	9.0	1.05	1.20	9.7	7.5
Sunshine:						
Nucellar	11.0	10.9	1.37	1.45	8.0	7.5
Old-line	10.7	10.2	1.28	1.38	8.4	7.4
Rangpur:						
Nucellar	10.4	10.7	1.24	1.46	8.4	7.3
Old-line	10.2	10.1	1.14	1.35	8.9	7.5

combination fruited as well or was as well adapted as the standard old-line-sour orange combination used industry-wide in Texas.

The results from this test do not necessarily apply to other nucellar grapefruit with a longer fruiting history. The source of buds for the nucellar trees in these trials was three young seedling nucellar trees which had not fruited. These trees were very juvenile; and nucellar trees propagated from such trees would be expected to be very vigorous, juvenile, and of unknown fruiting characteristics. This, in effect, is what occurred in our nucellar planting. Currently, we have another test of 8-year-old nucellar Redblush trees which were propagated from 20-year-old nucellar trees with a known fruiting history. These trees have not fruited long enough for us to draw any conclusions, but they are less thorny and less juvenile. It should be emphasized that the use of nucellar Redblush trees, propagated from nucellar trees without a fruiting history, or propagated from stabilized nucellar trees without a fruiting history under Valley conditions, is risky. There are no old-line Redblush trees in the Rio Grande Valley (or anywhere that we know of) that are known to be free of both xyloporosis and exocortis. Until we find a higher yielding virus-free nucellar, old-line Redblush trees on sour orange rootstock remain the combination best adapted to Valley conditions.

LITERATURE CITED

1. Cooper, W. C., E. O. Olson, Norman Maxwell, and George Otey. 1956. Review of studies on adaptability of citrus varieties as rootstocks for grapefruit in Texas. Proc. Rio Grande Valley Hort. Soc. 10:6-19.

2. Cooper, W. C., E. O. Olson, N. P. Maxwell, and A. V. Shull. 1957. Evaluation of citrus varieties as rootstock for various scion varieties in the Lower Rio Grande Valley of Texas. Proc. of Caribbean Region Amer. Soc. Hort. Sci.: 12-22.

3. Cooper, W. C., E. O. Olson, Norman Maxwell, and Arthur Shull. 1957. Orchard performance of young trees of red grapefruit on various rootstocks in Texas. Proc. Amer. Soc. Hort. Sci. 70:213-222.

4. Cooper, W. C., and Bruce J. Lime. 1960. Quality of Red grapefruit on old-line grapefruit varieties on xyloporosis- and exocortis-tolerant rootstocks. Proc. Rio Grande Valley Hort. Soc. 14:66-76.

5. Harding, Paul L., and D. F. Fisher. 1945. Seasonal changes in Florida grapefruit. Tech. Bull. No. 886. U. S. Department of Agriculture.

6. Young, Roger, and E. O. Olson. 1963. Freeze injury to citrus trees on various rootstocks in the Lower Rio Grande Valley of Texas. Proc. Amer. Soc. Hort. Sci. 83:337-343.

Juice Quality of Grapefruit Following June Versus September Applications of a 412 Paraffinic Petroleum Oil with Data on Control of Certain Pests[1]

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

Abstract: The June versus September (October 1967) applications of 412 paraffinic oil and malathion during 1965-1967 resulted in only slight differences in juice quality of the November grapefruit samples taken in 1965. Although a greater percentage solids was found in the samples following June oil, the increased percentage acid gave no greater solids to acid ratio than found following June and September oil application. Fruit from the non-oil treatment plots from trees on sour orange rootstock in 1967 were the only samples to meet minimum maturity standards.

Chaff scale was more abundant following malathion than oil applied in June and/or September.

Texas citrus mite populations were slightly smaller following dicofol-malathion than oil applications.

Texas legal maturity standards limit the early movement of grapefruit from the Lower Rio Grande Valley of Texas. Any grove care practice which affects the development of soluble solids or the lowering of percentage acid in the fruit is an important consideration in early shipment of fruit from this area. An experiment was initiated in 1965 to determine the possible effect on juice quality of grapefruit in November from 412 paraffinic oil and non-oil treatments applied in June and/or September and their effect on mite and scale populations.

Juice quality of grapefruit was found to be altered following the application of certain petroleum oils. Reduced soluble solids were found in December in grapefruit following application of 475 (50% distillation temperature by reduced pressure method) paraffinic oil in July in comparison with lighter oils (7). A smaller percentage of soluble solids was obtained following application of the above oil on September 1 than was obtained following application on July 1, July 15 or August 1 (8). The percentage acid also showed some degree of decrease. Soluble solids were also reduced when 448 and 410 oils were applied in September. Such evidence indicates that if oils are applied in September or if the oil is heavier than recommended (6), the possibility

[1] Technical Contribution No. 7365. Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas. These investigations were partially supported by Esso Research and Engineering Company, a research affiliate of Humble Oil & Refining Company.

[2] Associate Professor, Texas Agricultural Experiment Station, Weslaco, and graduate assistant, Mississippi State University of Applied Arts and Sciences, State College, Mississippi.

of grapefruit meeting minimum maturity requirements before December 1 is reduced.

Grapefruit cannot be shipped intrastate unless the fruit meets minimum maturity standards (12). The minimum ratios required respectively for the following minimum percentage solids are: 7.2 to 1 for 9%; 7 to 1 for 10%; 6.8 to 1 for 11% and 6.5 to 1 for 11.5%. A minimum fruit size may vary from year to year but is generally 3½ inches in diameter. Minimum juice varies according to the size of the fruit.

Chaff scale, *Parlatoria pergandii* Comstock, and the Texas citrus mite, *Eutetranychus banksi* (McGregor), were the principal pests requiring chemical control measures in this experiment. However, brown soft scale, *Coccus hesperidum* Linnaeus, showed evidence of increase on several ocasions and required control in September 1967, but the application had to be delayed until October because of the excessive rainfall. Chaff scale was the most numerous and widely distributed armored scale insect on citrus in the Valley area during the 1950s and the early 1960s (3 & 5). California red scale, *Aonidiella aurantii* (Maskell), was the most important scale insect of citrus in this area during the late 1920s and early 1930s (1 & 2). California red scale became less important in the 1940s but began increasing in importance since 1965. However, some growers have mistaken California red scale for chaff scale. Texas citrus mites were found to increase in numbers soon after the first yearly flush of growth came out and reached their greatest peak population of the year in the May-July period (4). A peak appeared earlier when dry weather prevailed during the spring period, and when such conditions appeared in the fall season, increases in populations were expected. Occasionally a December-January increase was found, but this period seemed to always be followed by a sharp decline in population before bloom. Consideration in control of this mite is usually given at the post-bloom, summer and fall periods.

MATERIALS AND METHODS

Plots in the red grapefruit grove at Weslaco were at least 8 trees in size and each treatment plot was replicated 4 times. Each plot had at least 2 trees each on sour orange and cleopatra rootstocks. Trees varied in height from 9 to 14 feet. Applications were made from a conventional hand gun sprayer by an accepted method for total coverage (9). Dosages of materials as shown in the tables are expressed in quantities of the various formulations per 100 gallons of diluted mixture: 99.75% oil, 42% EC dicofol (Kelthane), 50% WP or 12.3% EC tetradifon (Tedion), 95% EC (9.7 lb/gal) malathion, 75% WP zineb and 80% WP carbaryl (Sevin). The oil had the following physical properties: 412°F-50% distillation temperature (10 mm Mg.), 55°F-boiling range (10-90%), +15°F-pour point, 96%-unsulfonated residue, and 74%-carbon atoms in paraffinic structure (11). Triton X-207 surfactant was used at 0.25% (volume) with the oil. Sponto M was mixed with the technical malathion at 0.35% (volume).

An average fruit-diameter size was determined before juice analysis samples were taken. Fruits were selected which were the average diameter plus or minus 3 mm from the mean and each sample was comprised of 16 fruits. Fruit samples from trees on sour orange rootstock were run separately from those from trees on cleopatra rootstock.

Juice was removed by a hand-extractor unit powered by a ¼-hp motor and screened through a 16-mesh stainless-steel screen. Volume and weight of juice were determined for each sample.

Acid content was determined by titration with standard sodium hydroxide and is reported as anhydrous citric. A hand refractometer with temperature correction was used for determination of percentage soluble solids in accord with an established procedure (10).

The Duncan multiple range test, at the 5% level, was used for comparing differences for possible significance. Data were analyzed by Data Processing Center at College Station.

Scale populations were determined by a described method (5) except that no more than 10 scale per leaf were counted. Mites were counted under 20X magnification after removal from each 40-leaf sample with a standard mite-brushing machine.

RESULTS

Juice Analysis. Fruit sizes were too small in the 1965 and 1966 samples to meet minimum regulated size. The fruit size was 3½ inches in diameter in 1967 and the fruit had more than adequate juice. Heavy September rains were probably an important factor in fruit sizes being larger than in the previous 2 years.

Percentage soluble solids for non-oil plot samples in 1965 was smaller than for June oil samples but was no different from September oil or June-September oil samples (Table 1). Samples from June oil or September oil plots showed greater percentage solids than samples from the all-oil plots. Percentage soluble solids was smaller in fruit samples from trees on cleopatra rootstock with all samples from the various treatment plots having 10% or greater soluble solids in fruit from trees on sour orange rootstock.

No differences were found in percentage soluble solids among samples in 1966 or 1967. Percentage soluble solids did not differ among the various treatment samples of fruit from trees on the 2 rootstocks in 1966, but a difference was found in 1967 with the non-oil and September oil samples.

Differences in percentage acid were found only in 1965. June oil treatment samples had more acid than other treatment samples. Fruit from trees on cleopatra rootstock had more acid than fruit from trees on sour orange rootstock.

Table 1. Effect of 412 paraffinic oil applied in June and/or September (October 1967) on juice quality of grapefruit at Weslaco, Texas[a].

Treatment[b]	*Date*	*Soluble solids (%)*	*Acid (%)*	*Solids/ acid*	*Soluble solids (%)*	*Acid (%)*	*Solids/ acid*	*Soluble solids (%)*	*Acid (%)*	*Solids/ acid*
		Combined			*On Sour Orange Rootstock*			*On Cleopatra Rootstock*		
					November 8, 1965					
A	6/2-3	9.9ab	1.38a	7.1ab	10.0	1.39	7.2	9.8	1.38	7.1
B	9/13-14	9.8a	1.39a	7.1a	10.0	1.38	7.2	9.6	1.39	6.9
C		10.1 c	1.45 b	7.0a	10.2	1.42	7.2	10.0	1.48	6.8
D		10.1 bc	1.39a	7.3 b	10.2	1.34	7.7	9.9	1.45	6.9
					November 7, 1966					
A	6/11-13	10.5a	1.56a	6.8a	10.6	1.53	6.9	10.5	1.59	6.6
B	9/14-15	10.4a	1.57a	6.6a	10.5	1.58	6.7	10.2	1.57	6.5
C		10.6a	1.58a	6.7a	10.6	1.58	6.7	10.6	1.58	6.7
D		10.5a	1.56a	6.7a	10.6	1.55	6.9	10.3	1.56	6.6
					November 14, 1967					
A	6/19	9.3a	1.33a	7.0a	9.4	1.30	7.2	9.2	1.36	6.8
B	10/17-18	9.3a	1.32a	7.0a	9.3	1.33	7.0	9.2	1.31	7.0
C		9.3a	1.36a	6.8a	9.4	1.34	7.0	9.2	1.38	6.7
D		9.3a	1.39a	6.7a	9.5	1.38	6.9	9.1	1.40	6.5

[a] Values followed by the same letter do not differ significantly at the 5% level by Duncan's Multiple range test.

[b] A=June and September non-oil. B=June and September oil. C=June oil, September non-oil. D=June non-oil, September oil. All treatments included 0.5 lb. zineb (except October 1967 when 1 lb. zineb + 0.5 lb. carbaryl included). Oil applied at 1.6%. Non-oil contained 293 ml malathion + 378 ml dicofol (except June 1966-946 ml tetradifon). June 1966 oil application included 0.5 lb. tetradifon.

The soluble solids to acid ratios among treatment samples differed only in 1965. September oil samples had greater ratios than all-oil and June oil samples. Ratios were smaller 9 of 12 times in fruit from trees on cleopatra rootstock. Fruit from trees on sour orange rootstock had greater ratios than fruit from trees on cleopatra rootstock in 1966 and 1967.

Ony the non-oil treatment samples from trees on sour orange rootstock taken November 14, 1967, met the minimum maturity standards. The percentages of soluble solids and acid were smaller in 1967, but the solids to acid ratio, quantity of juice and fruit size were adequate. In 1966, solids and acid were greater than in 1965 or 1967 and ratios were small. The variability in percentages of solids and acid was of a minor nature among samples in each of the 3 years. The greatest differences were found between fruit samples from trees on the 2 rootstocks.

Chaff Scale. A much greater reduction in the number of live scale was found after June oil than June malathion treatments (Table 2). The number of live scale after June oil remained smaller through the September count except in the September 6, 1966, count when the scale population from the all-oil plots was greater than from the September oil plots. Although a few more live scale were found in the June oil plots than the non-oil plots on September 25, 1967, the counts required more leaves from the June oil plots and fewer scale were counted. More parasites had increased with the larger scale population in the non-oil plots to reduce this larger scale population. A smaller scale to parasite ratio was found in August and September 1965 following oil than following malathion. Parasites were almost absent from the samples following June application in 1966. In 1967, parasite numbers were reduced following June application, but parasites were present in all plot samples and increased to larger numbers in the August and September counts. The scale to parasite ratio was smaller in the September count in 1965 than in 1967. In both years, live scale numbers were reduced in the September counts.

Following September (October in 1967) applications, a greater reduction in live scale was found in the oil plots in 1966 and 1967. In 1965, scale populations were very small after application and when the first count was made on January 28, 1966, parasites were only found in the oil plot samples. A greater number of live scale was found on fewer leaves in the September malathion plots. More live scale were found in September malathion plots in the 3-month period following application in 1966. More parasites were also found with the greater number of live scale beginning in November. More scale were generally found in the October 1967 malathion-treated plots during the 5-month period after application than in the oil plots. The all-oil plots in 1967 had the smallest number of live scale and scale counted than other plot samples, and more leaves were required for the counts from these plots.

Texas Citrus Mites. A larger pre-June-treatment population of Texas citrus mites was found in 1965 than in the subsequent 2 years (Table 3).

Table 2. Chaff scale and parasite populations before and after June versus September (October 1967) applications of 412 oil and malathion to grapefruit trees at Weslaco, Texas.

Treatment[a] Date	Sampling Date	*June : malathion Sept. : malathion*					*June : oil Sept. : oil*					*June : oil Sept. : malathion*					*June : malathion Sept. : oil*				
		AS[b]	*P*[c]	*LP*[d]	*NS*[e]	*NL*[f]	*AS*	*P*	*LP*	*NS*	*NL*	*AS*	*P*	*LP*	*NS*	*NL*	*AS*	*P*	*LP*	*NS*	*NL*
6/1&2/65	5/19	190	89	28	400	182	140	73	34	400	182	179	92	27	400	170	185	100	35	400	175
	7/13	106	57	0	339	83	33	59	0	373	62	13	81	9	366	100	111	41	0	362	96
	8/20	227	41	5	400	61	42	64	8	400	73	86	50	18	400	93	216	39	13	400	64
9/13&14	9/7	157	159	112	390	84	57	138	92	347	124	58	162	78	336	107	87	187	108	400	72
	1/28/66[g]	42	54	0	200	47	19	24	19	144	67	30	14	0	72	32	34	21	4	204	56
6/11-13	5/20	87	133	7	400	93	64	90	2	343	113	78	99	56	298	104	114	130	28	400	102
	7/15[g]	60	102	0	326	128	8	36	0	118	128	23	88	2	295	125	88	55	2	285	126
	8/17	156	59	1	393	110	34	47	2	288	110	74	61	0	354	123	143	57	0	335	126
9/14-15	9/6	245	28	0	400	84	231	77	0	400	84	78	75	0	319	114	185	40	0	357	111
	10/10	46	44	0	318	118	13	16	0	213	128	66	50	2	384	116	4	23	0	305	120
	11/2	83	51	5	400	83	25	89	1	376	92	100	94	16	400	96	13	63	1	380	98
	12/28	79	57	13	385	96	24	101	15	400	90	98	74	33	400	77	74	55	3	396	105
6/19/67	6/16	185	136	43	400	87	216	129	50	400	81	273	77	28	400	103	173	101	33	360	118
	7/28	137	69	3	400	78	30	130	2	381	81	74	76	1	400	84	154	83	3	400	84
	8/31	191	123	64	400	76	119	121	29	400	85	122	129	54	400	72	216	101	58	400	74
10/17	9/25	56	133	31	400	58	46	113	10	302	119	64	125	16	393	95	99	159	33	377	93
	12/14	37	146	0	400	101	3	107	0	279	126	23	76	0	233	110	7	166	0	400	91
	1/31/68	66	154	1	400	103	16	101	1	253	128	64	140	1	386	107	20	166	1	400	79
	2/26	39	156	2	400	93	40	63	0	254	128	41	102	0	320	116	44	99	0	380	115
	3/25	72	136	4	400	80	20	33	0	182	128	114	80	1	297	125	75	94	0	352	126

[a] See Table 1 or text for further information
[b] Number of live scale
[c] Number of parasitized scale
[d] Number of scale with live, immature parasites
[e] Total scale counted in samples
[f] Number of leaves (of 128 total) examined for scale counts from 4 replicates
[g] Reduced scale collection from very small populations.

Table 3. Texas citrus mites and eggs per leaf following 412 oil versus non-oil treatments in June and September (October 1967) to grapefruit trees at Weslaco, Texas, 1965-67.

Treatment[a] *Date*	*Sampling Date*	*June : malathion-dicofol Sept. : malathion-dicofol*		*June : oil Sept. : oil*		*June : oil Sept. : malathion-dicofol*		*June : malathion-dicofol Sept. : oil*	
		Mites	*Eggs*	*Mites*	*Eggs*	*Mites*	*Eggs*	*Mites*	*Eggs*
6/1-2/65	5/28	17.48	14.05	17.59	15.62	14.62	12.15	18.25	15.90
	6/21	.44	1.18	.40	1.11	.40	.93	.66	1.43
	7/20	.02	.00	.04	.04	.60	.40	.00	.00
	8/17	.11	.69	.68	1.19	2.04	2.70	.31	.59
9/13-14	9/3	1.16	1.66	1.14	1.59	3.41	5.60	2.40	3.81
	10/28	.01	.05	.02	.00	.05	.08	.06	.10
	12/23	.05	.00	1.93	2.68	.37	.26	.91	.76
	3/7/66	.00	.02	2.75	10.50	.87	1.12	.20	5.50
6/11[b]	6/10	3.86	6.88	3.78	5.68	2.38	5.42	4.00	5.71
	7/14	.00	.10	.01	.18	.00	.08	.01	.10
9/14-15	9/3	.00	.00	.14	.08	.04	.04	.06	.08
	11/2	.02	.28	.08	.16	.04	.20	.02	.08
	12/7	.02	.09	.13	.15	.13	.11	.26	.49
	12/27	.05	.05	.04	.01	.05	.15	.09	.23
	3/31/67	2.38	2.65	2.59	2.96	.95	1.89	4.43	4.29
	4/25	49.12	95.80	37.95	68.15	54.60	85.85	54.25	73.30
6/19[d]	6/9	.00	.00	.00	.00	.00	.00	.00	.00
	7/10	.00	.00	.01	.01	.00	.00	.00	.00
	8/4	.00	.00	.11	.63	.19	.60	.00	.00
	8/31	.25	.34	.65	.91	1.04	1.13	.19	.18
10/18[e]	9/25	.01	.00	.05	.01	.00	.00	.05	.01
	12/13	.00	.00	.00	.00	.00	.00	.00	.00
	3/25/68	.00	.00	.00	.00	.00	.00	.01	.01

[a] Oils applied at 1.6%. Non-oil contained 293 ml malathion + 378 ml dicofol (except 6/11/66). All treatments included 0.5 lb zineb.
[b] On 3/29 & 30, applied 378 ml dicofol to all plots
[c] Oil treatments included 0.5 lb tetradifon. Non-oil; 946 ml tetradifon in place of dicofol
[d] On 5/5 & 6, applied 378 ml dicofol + 1 lb chlorobenzilate to all plots
[e] All treatments included 0.5 lb carbaryl

The initial reduction of mites was about the same with 412 oil and malathion-dicofol combination while in the August count the population in the oil plots was slightly greater. The mite population was quite variable in the September count and was increasing in numbers. The smaller pre-treatment population count in 1966 followed a dicofol application to all plots on March 29 and 30. Very small populations were found through the September count with the 412 oil-tetradifon and malathion-tetradifon treatments. In 1967, the mite population increased to very large numbers by April 29. So, a dicofol-chlorobenzilate application was made on May 5 and 6. No mites were found in the counts just prior to June application. A slightly greater population was found in the 412 oil plots than in the malathion-dicofol plots on August 31. Mite populations dropped very sharply by September 25 following 12.99 inches of rainfall (7.33 inches fell on September 21).

Mite populations were larger in the September counts before treatment in 1965 than in the subsequent 2 years. On December 23, mite populations were slightly larger in the oil plots and were larger than in the December count in 1966 and 1967. Oil plots had larger mite populations in March 1966 and 1967 than in 1968.

LITERATURE CITED

1. Clark, S. W. 1937. Annual report. Texas Agricultural Experiment Station No. 15, Weslaco, (Unpublished).

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

3. Dean, H. A. 1955. Factors affecting biological control of scale insects on Texas citrus. J. Econ. Entomol. 48(4):444-7.

4. Dean, H. A. 1959. Seasonal distribution of mites on Texas grapefruit. J. Econ. Entomol. 52(2):228-232.

5. Dean, H. A. 1965. An *Aphytis complex* (Hymenoptera: Eulophidae) of chaff scale. Ann. Entomol. Soc. Am. 58(2): 142-5.

6. Dean, H. A., and J. C. Bailey. 1961. Properties of spray oils for grapefruit in the Rio Grande Valley of Texas for 1961. J. Rio Grande Valley Hort. Soc. 15:10-11.

7. Dean, H. A., and J. C. Bailey. 1963. Responses of grapefruit trees to various spray oil fractions. J. Econ. Entomol. 56(5):547-551.

8. Dean, H. A., R. C. Halter, C. E. Hoelscher and J. C. Bailey. 1965. Effects of several oils and influence of deposit rates on the juice quality and maturity of grapefruit in Texas. J. Rio Grande Valley Hort. Soc. 19:3-11.

9. Riehl, L. A. 1961. A routine system for spray application manually to citrus. J. Rio Grande Valley Hort. Soc. 15:3-9.

10. Sinclair, W. B., E. T. Bartholomew, and W. Ebeling. 1941. Comparative effects of oil spray and hydrocyanic acid fumigation on the composition of orange fruits. J. Econ. Entomol. 34(6):821-9.

11. Smith, E. E. 1953. Analysis of lubricating oils: Part 1, Correlation of physical properties and structural composition of lubricating oils. Ohio State Univ. Eng. Exp. Sta. Bull. 152. p. 1-31.

12. White, J. C. 1959. Fresh fruit and vegetable inspection laws. Tex. Dept. Agr. A58-A. Pp. 29-30.

Oil Deposit on Grapefruit Leaves with 3 Types of Spray Equipment in Relation to Control of Certain Citrus Pests[1]

H. A. Dean, M. T. Waddell, and Art Shull[2]

Abstract: Following application of oil formulated with 0.3% (volume) Triton X-207, the average micrograms of oil per square centimeter of grapefruit leaf surface with the respective spray equipment were as follows: 76-hand rig, 71-concentrate and 105-air blast. Oil deposit was more uniform with the hand rig while more oil was deposited with the concentrate sprayer in the skirt area and less in the top and inside portions of the tree.

Although populations of California red scale were small, more scale were found in plots sprayed with the concentrate and air blast (½ dosage) sprayers than with the hand rig and air blast sprayers.

Oil applied with various types of spray equipment in Texas has given considerable variation in the control of scale insects and mites. Coverage of all plant parts is a requirement with any scalicide if the desired control is to be attained. Armored scale insects move about only during the first 2 to 5 days after hatching and do not move after they settle down to feed. An experiment was conducted at Rio Farms, Inc., at Monte Alto, Texas, during July 1967 to determine tree coverage with 3 types of spray equipment through oil deposit determinations on leaves. Counts of mites and California red scale, *Aonidiella aurantii* (Maskell), were made during the 8-month period following application.

Wind speed is a limiting factor for best coverage much of the time in the Lower Rio Grande Valley of Texas. Scheduled applications must be accomplished in wind speeds of 10 to 18 mph or greater in order that large acreages of trees can be covered. Special adjustments must be considered from grove to grove with any type of spray equipment in accomplishing the best coverage possible. Night spraying has also been done to avoid application during such windy conditions. Florida recommendations suggest spray application to citrus be discontinued when wind speed is above 8 mph (5).

Petroleum oil sprays have been investigated by several workers to determine how oil kills armored scale insects. The lethal action of oil

1 Technical Contribution No. 7367, Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas. These investigations were partially supported by Esso Research and Engineering Company, a Research Affiliate of Humble Oil & Refining Company.

2 Associate Professor, TAES, Weslaco; Research Specialist, Baytown Petroleum Research Laboratory, Esso Research and Engineering Company; Citrus Production Manager, Rio Farms, Inc., Monte Alto, Texas.

is due to suffocation brought about by the oil penetrating and blocking the tracheae (3). It was observed that often the oil does not reach the tracheae, and in this case death may be caused by a "prolonged impairment of physiological processes such as might be induced by the presence of oil in the scale covering or in contact with the derm of the insect's body" (8). Later evidence gave support that the majority of California red scale was killed with oil by tracheal penetration of the oil, although some kill was also found from oil penetration through the armor of the scale. Immature scale were killed more easily and crawlers had difficulty settling on foliage for some time after application with the recommended field dosage of oil (4). Any scalicide in use today must cover the scale to produce effective control. Since scale insects do not move after settling, coverage of a tree with dense foliage is very important with any type of spray equipment employed.

MATERIALS AND METHODS

The following types of spray equipment were employed for application: conventional hand rig, Hardie air blast[3], and Marlow concentrate[3]. The hand rig was operated at 600 psi with single nozzle guns and spray was also applied from a tower on the rig above the tree tops. A coverage technique for spraying was followed to achieve full coverage (7). A 97,500 ft^3 min air blast sprayer was operated at 125 psi with 2 sets of nozzles on each side. The orifice sizes from top to bottom were as follows: 10, 10, 10, 10, 8, 8, 7, 6 and 6. Some 60% of the liquid was directed into the top half of the trees with such a nozzle arrangement. This sprayer was pulled at 1 mph and dilution rate was 1X. The concentrate machine was a single head sprayer operated at a speed of 1 mph and no water was used in the tank. The 6 orifices were adjusted alike as recommended, however, better coverage might have been possible had more liquid been directed into the top half of the trees.

Physical properties of the petroleum oil were as follows: 50% distillation point at 10 mm Hg.-443°F, 10-90% boiling range-65°F, unsulfonated residue-96%, pour point- +15°F and % carbon atoms in paraffinic structures-69.7. The oil contained 0.3% (by volume) Triton X-207 for emulsification. The diluted mixture contained 1.6% oil plus 1 lb 75% WP zineb. The equivalent amount of zineb was used with oil in the concentrate sprayer. The 15-foot grapefruit trees received the following amount of actual oil per tree from the indicated sprayer: 1.0 quart—hand rig, 0.93 quart—air blast, and 0.87 quart—concentrate. Wind speed was approximately 5 to 8 mph at the time of application and was not as great as usually found during July after 8 a.m.

Leaves were collected from the top, skirt and inside portions of the tree after the oil had dried or had soaked into the leaves. One leaf was

[3] Mention of proprietary equipment does not necessarily imply endorsement by Texas Agricultural Experiment Station.

collected from the southeast and northeast quadrant on each of 5 trees for a total of 10 leaves from the east half of the trees in each plot and the leaf blades areas were measured by superimposing over patterns of leaves (2). Leaves were then collected from the west quadrants of the same trees. The 10 leaf blades were clipped from their petioles and placed in a screw-capped jar with 150 ml iso-octane for oil extraction from the leaves. Coded samples were then sent to the Baytown Research and Development Division of Esso Research and Engineering Company for oil analyses using a gas chromatography instrument (6). Leaf sizes were selected so that 10 leaf blades comprised at least 800 cm^2 of surface area. Samples were collected from 3 of the 4 replicates for a total of 18 samples from each treatment.

Scale populations were determined by a described method (1) except that no more than 10 scale per leaf were counted. Mites were counted under 20X magnification after removal from each 40-leaf sample with a standard mite-brushing machine. The most numerous mites in the samples were the Texas citrus mite, *Eutetranychus banksi* (McGregor), and the predaceous phytoseiid mites.

The Duncan multiple range test, at the 5% level, was used for comparing oil deposit levels for possible significance. Data were analyzed by Data Processing Center at College Station.

RESULTS

Oil Deposit. Oil deposit on leaves was quite uniform in all portions of the trees with the hand gun and air blast sprayers, but the latter sprayer deposited an average of 29.0 micrograms more oil with this oil formulated with 0.3% (volume) Triton X-207 (Table 1). With the concentrate sprayer, oil deposit was greater in the skirt portion of the tree than in the top or inside portions. Average oil deposit with the concentrate sprayer was 29.2 and 17.4 micrograms less in the top and inside portions of the tree than with the hand gun sprayer.

The smallest and largest oil deposits from the different portions of the tree varied less with the hand gun rig than with the other sprayers. These differences were 22.4, 50.5 and 59.5 micrograms respectively from the top portion of the trees for the hand rig, air blast and concentrate sprayers. Such differences in the skirt samples for the respective sprayers were as follows: 26.5—hand rig, 28.0—air blast and 48.9—concentrate sprayers. Differences between the largest and smallest deposits from inside samples were as follows for the respective types of equipment: 28.5—hand rig, 32.2—air blast and 32.7—concentrate sprayers.

Oil deposit was greater in the top of the trees with the air blast sprayer than with the concentrate sprayer. Differences in oil deposit were not great enough between the air blast and hand gun sprayers to be significant.

Table 1. Average oil deposit, micrograms per square centimeter, on leaves in various portions of grapefruit trees following application with 3 different spray rigs.

Type of Spray Equipment	*Oil Application*	*Top*			*Skirt*			*Inside*		
	Actual oil/tree quart	*East*	*West*	*Average*	*East*	*West*	*Average*	*East*	*West*	*Average*
Hand Rig	1.0	80.3	82.8	81.6 ab	84.2	70.2	77.2 b	67.1	73.6	70.4 b
Marlow Concentrate	.87	57.2	47.6	52.4 b	113.4	101.1	107.2 a	58.6	47.2	52.9 c
Hardie Air Blast	.93	114.9	115.4	115.2 a	104.4	87.9	96.2 ab	104.8	104.9	104.8 a

Values followed by the same letter do not differ significantly at the 5% level by Duncan's multiple range test.

Table 2. California red scale and parasite populations before and after July oil treatments applied from different spray equipment.

Date	*Hand Rig*					*½ Dosage Air Blast*					*Concentrate*					*Air Blast*				
	AS[1]	*P*[2]	*LP*[3]	*NS*[4]	*NL*[5]	*AS*	*P*	*LP*	*NS*	*NL*	*AS*	*P*	*LP*	*NS*	*NL*	*AS*	*P*	*LP*	*NS*	*NL*
7-5-67	138	19	4	328	120	162	67	9	395	96	178	40	6	400	95	126	65	11	360	103
7-11, 13	——Sprayed 7-11——					——Sprayed 7-13——					——Sprayed 7-13——					——Sprayed 7-11——				
8-2	1	73	—	398	121	8	73	—	362	125	19	69	—	360	125	2	65	—	326	125
8-21	8	41	—	356	128	25	53	—	385	126	24	75	2	382	92	10	65	—	359	122
9-11	6	64	—	382	126	8	55	—	331	112	31	85	2	384	102	9	109	—	377	105
10-12	14	65	1	320	128	13	77	—	307	128	22	69	1	365	110	36	107	—	351	122
1-22	15	95	—	298	116	104	165	3	381	128	97	36	—	261	128	54	64	—	278	127
2-19	53	41	—	234	128	131	33	4	260	122	116	26	3	272	128	85	41	—	227	128
3-20	95	50	—	263	128	210	35	7	279	128	193	36	3	291	128	105	34	1	219	128

[1] Number of live scale. [2] Number of parasitized scale. [3] Number of scale with live, immature parasites. [4] Total scale counted in samples. [5] Number of leaves (of 128 total) examined for scale counts from 4 replicates.

In the skirt area, a greater oil deposit was found with the concentrate sprayer than with the hand gun rig, while the air blast and hand gun sprayer resulted in like deposit.

Oil deposit in the inside portions was greater with the air blast sprayer than with the other rigs while oil deposit with the hand gun sprayer was greater than with the concentrate sprayer.

The analyses did not show a difference in oil deposit from the combined samples from the east and west sides of the trees. However, there was a greater deposit on the east side from the skirt area. There was no difference in oil deposit between replications.

California red scale. The percentage of live scale varied from 35 to 44.5% in the various treatment plots before application (Table 2). Although the collection of scale-infested leaves was much easier before treatment, the general population of scale was considered light to moderate and as uniform as might be expected.

During the 8-month period following application, California red scale were in very small population numbers, except for an increasing trend during the latter 2 months. Some 18 inches of rain fell during the September 20-24 period when hurricane Beulah passed through the area. Prior to that time, there was a very small increase from populations less than 95% of that before treatment, except in the concentrate sprayer plots. A few parasites were found in these latter plots.

Populations of scale were so small on December 4 that it was not considered worthwhile to make a population count. Some scale on fruit were examined and live parasites varied from 0.0 to 17 per 100 scale examined. The ascending order of plots with more live scale during the last 2 months was as follows: hand rig, air blast, concentrate and ½ dosage air blast. Collections of scale-infested leaves also showed the smallest number of live scale from the hand rig and air blast sprayer plots. Parasites were more numerous in the samples which had more live scale.

Mites. Texas citrus mites remained in small numbers after July application through the October 12 count (Table 3). The heavy rainfall in September, no doubt, curtailed the increase during the late-September, early-October period. Mites did increase thereafter as shown by the December 4 counts. However, a very sharp decline in populations occurred in December in this experiment as well as in other experiments. Certainly the large number of predaceous phytoseid mites could have been a very important factor in this decline. Replicate 1 of the hand rig plots was in the dustiest location of any of the plots in the experiment and had 85% of the mites and 76% of the eggs found on December 4 in the total from the 4 plots sampled.

Table 3. Numbers of Texas citrus mites and eggs and predaceous mites per 80 leaves following oil application from various types of spray equipment at Monte Alto, Texas.

	Hand Rig			*½ Dosage-Air Blast*			*Concentrate*			*Air Blast*		
Date	*TCM*	*TCME*	*PM*[1]	*TCM*	*TCME*	*PM*	*TCM*	*TCME*	*PM*	*TCM*	*TCME*	*PM*
	---Sprayed 7-11---			---Sprayed 7-13---			---Sprayed 7-13---			---Sprayed 7-11---		
8-2-67	—	—	—	—	—	1	—	—	—	—	—	—
8-21	—	—	—	2	2	—	1	2	—	—	—	—
9-11	1	7	—	—	1	—	4	3	—	1	5	—
10-12	1	1	—	4	7	—	9	5	2	6	4	—
12-4	274[2]	455	42	182	369	84	209	292	100	384	595	40
1-22-68	—	—	4	—	—	1	—	—	6	—	—	4
2-19	—	—	5	—	—	10	—	—	15	—	—	7
3-20	—	1	—	—	1	3	—	—	3	—	—	5

[1] Predaceous phytoseid mites.

[2] Replicate 1 samples in southeast corner position had 85% of mites and 76% of eggs in these totals.

LITERATURE CITED

1. Dean, H. A. 1961. *Aphytis lepidosaphes* (Hymenoptera: Chalcidoidea), an introduced parasite of purple scale. Ann. Entomol. Soc. Amer. 54:918-20.

2. Dean, H. A., E. L. Wilson, J. C. Bailey, R. W. White, and L. A. Riehl. 1964. A field technique for oil deposit determination on citrus through colorimetric analysis. J. Econ. Entomol. 57(4):458-461.

3. De Ong, E. R., H. Knight, and J. C. Chamberlin. 1927. A preliminary study of petroleum oil as an insecticide for citrus trees. Hilgardia 2:251-384.

4. Ebeling, W. 1936. Effect of oil spray on California red scale at various stages of development. Hilgardia 10(4):95-125.

5. Florida citrus spray and dust schedule 1968.

6. Halter, R. C., L. A. Riehl, T. Aczel, and H. A. Dean. 1968. Field technique for determination of oil deposit on foliage using gas chromatography. (In preparation for publication).

7. Riehl, L. A. 1961. A routine system for spray application manually to citrus. J. Rio Grande Valley Hort. Soc. 15:3-9.

8. Smith, R. H. 1932. Experiments with toxic substances in highly refined spray oils. J. Econ. Entomol. 5:988-990.

The Use of an Anti-transpirant on Newly-set Grapefruit Trees[1]

JOHN E. FUCIK[2]

Abstract: An anti-transpirant spray of an acrylic copolymer type was sprayed on the foliage of Redblush grapefruit trees. The sprays were applied after removing the trees from the nursery and two days before transplanting to the field. Comparisons of the survival and growth of sprayed to unsprayed trees 18 months after transplanting showed no apparent benefits resulted from the anti-transpirant spray. Selected weather data for the 6 month period after transplanting indicated it unlikely the trees were subjected to any extended periods of severe moisture stress. Situations where anti-transpirants might prove beneficial are suggested for future investigation.

INTRODUCTION

In transplanting trees it is important to balance water loss and water absorption. This is commonly achieved by removing a third to a half of the plant's leaf surface to compensate for the roots lost in transplanting. Recently chemicals have been found to reduce the amount of water transpired by plants (2,5,7). These materials fall into two general classes, those which operate directly on the opening and closing of leaf stomata and those which cover the plant surface with a film or barrier impervious to water. Examples of these latter materials are waxy emulsions, liquid plastics, and high molecular weight fatty-alcohols. In some ornamental and nursery plants transpiration has been reduced by 40% under conditions favoring high evaporative water loss (7). Gardner and Horanic studied the effect of a vinyl polymer emulsion and hexadecanol on the transpiration of container grown Hamlin oranges on four different rootstocks (3). A 20% solution of the vinyl emulsion reduced transpiration by 25% and the hexadecanol by 80%. In neither case did the effects last more than 5 days. The use of an acrylic co-polymer anti-transpirant on the survival and growth of transplanted grapefruit is reported here.

MATERIALS AND PROCEDURE

Nursery trees of Redblush grapefruit on sour orange rootstock were used in this experiment. The trees had been dug and the roots balled and burlaped the day before the treatment was applied. About half of the leaf surface had been removed by pruning prior to digging the trees.

The trees were sprayed with a 20% solution of acrylic copolymer

[1] Cooperative citrus research of Texas A&I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.

[2] Ass't. Prof. of Agriculture, Texas A&I University Citrus Center, Weslaco.

(FOLI-GARD)[3] on September 21 and planted on September 23. Five sprayed trees and two unsprayed control trees were included in each of four replications. The trees were randomly assigned to plots located in a 10 acre field on the South Research Farm of Texas A&I University Citrus Center, Weslaco, Texas. Soils in the plots were Hidalgo sandy loam and sandy clay loam. The trees were irrigated within a day after planting. Plots were maintained under a system of chemical weed control with no tillage. Urea fertilizer at the rates of 36 and 75 lbs of N an acre was applied in June and December 1967.

Treatment responses were assessed by comparing the survival, height, and trunk diameter of sprayed to unsprayed trees. These determinations were made in April 1968. Trunk diameter was measured 12 in. above the soil line. Since the tree canopies were of comparable shape, tree height was taken from ground level to the highest point of the main mass of the canopy. Statistical inferences were based on the analysis of variance of these measurements.

RESULTS and DISCUSSION

While methods and instruments have been divised for measuring plant transpiration in the field, for commercial usage the effectiveness of an anti-transpirant should be expressable in terms of survival, growth, or yield increases (1,4,8). In Table 1 the trunk diameter, tree height and survival of the trees sprayed with the anti-transpirant are compared to the untreated trees. Any benefits provided by the anti-transpirant were not reflected by significant differences in growth or survival of the trees after 18 months in the field.

Table 1. The effect of an anti-transpirant spray on the growth and survival of grapefruit trees. Data taken 18 months after transplanting.

	Trunk Diam.	*Tree Height*	*Tree Survival*
Sprayed with anti-transpirant	1.38 in.	49.0 in.	100%
Not sprayed	1.34 in.	49.0 in.	100%

The weather data in Table 2 represent some of the climatic factors most likely to affect the tree's water status. The data cover the six month period after planting which is a critical time in getting trees established. This period also would include the maximum period of effectiveness for the anti-transpirants.

Favorable fall moisture conditions followed by cool winter temperatures would not have created many periods of high moisture stress. This situation coupled with the reduction in leaf surface from pruning could account for the lack of a growth response to the anti-transpirant

[3] Manufactured by E-Z Flow Chemical Company, Lexington, Kentucky.

spray. Under the weather conditions experienced during the usual south Texas fall-winter season this type of anti-transpirant appears to offer little advantage in transplanting survival and subsequent growth of grapefruit trees.

Some anti-transpirant materials could prove effective under special situations. For example, where dug trees are to be held for an extended period before planting; or where transplanting is followed by hot, dry weather or dessicating winds (6). It is possible that anti-transpirants might also eliminate the need for the usual reduction in leaf surface prior to digging. By increasing photosynthesis while reducing water loss this greater leaf surface might aid in more rapid establishment of the transplanted tree. Testing of these possibilities is contemplated in future experiments with anti-transpirant materials.

LITERATURE CITED

1. Cain, R. F. 1942. Comparative transpiration rates of peaches and citrus. Proc. Amer. Soc. Hort. Sci. 40:79-83.

2. Gale, J. and R. M. Hagan. 1966. Plant antitranspirants. Ann. Rev. Plant Physiol. 17:269-282.

Table 2. Bi-weekly weather data affecting water status of trees. Thermograph, standard rain gauge, and 4 inch evaporating pan were used for temperature, rainfall, and evaporation records. Water added for an irrigation is figured from the long term average.

	TEMPERATURES			
Date	*Avg. Weekly High*	*Range*	*Rain (R) or Irrigation (I)*	*Evaporation (Total)*
Sept. 29 - Oct. 12 1966	87 F.	58-96 F.	1.3 in. (R) 4.0 in. (I)	2.8 in.
Oct. 13 - 26	79 F.	50-84 F.	4.3 in. (R)	2.6 in.
Oct. 27 - Nov. 9	78 F.	36-83 F.	0	2.7 in.
Nov. 10 - 23	72 F.	53-89 F.	4.0 in. (R)	2.2 in.
Nov. 24 - Dec. 11	76 F.	32-86 F.	0	2.3 in.
Dec. 12 - 25	70 F.	28-82 F.	0	2.1 in.
Dec. 26 - Jan. 8 (1967)	66 F.	28-82 F.	0	1.8 in.
Jan. 9 - 22	62 F.	31-79 F.	1.6 in. (R) 4.0 in. (I)	1.1 in.
Jan. 23 - Feb. 5	74 F.	38-82 F.	0	1.8 in.
Feb. 6 - 19	72 F.	30-87 F.	.2 in. (R)	2.4 in.
Feb. 20 - Mar. 5	72 F.	41-87 F.	.6 in. (R)	2.2 in.
Mar. 6 - 19	81 F.	50-89 F.	4.0 in. (I)	3.2 in.
Mar. 20 - Apr. 2	84 F.	65-88 F.	.8 in. (R)	3.1 in.
Apr. 3 - 16	88 F.	60-96 F.	0	4.0 in.
Apr. 17 - 30	90 F.	66-96 F.	4.0 in. (I)	4.4 in.

3. Gardner, F. E. and G. E. Horanic. 1967. Transpiration rates of container grown orange trees on four rootstocks and the effect of two antitranspirants. Proc. Amer. Soc. Hort. Sci. 91:128-137.

4. Hashemi, F. and J. F. Gerber. 1967. Estimating evapotranspiration from a citrus orchard with weather data. Proc. Amer. Soc. Hort. Sci. 91:173-179.

5. Pallas, James E. Jr., Anson R. Bertrand, Donald G. Harris, Charles B. Elkins, Jr., and Clyde L. Parks. 1962. Research in plant transpiration: 1962. Ag. Res. Serv., U.S.D.A. Prod. Res. Report No. 87. 56 pp.

6. Salter, P. J. and J. E. Goode. 1967. Crop responses to water at different stages of growth, Research Rev. No. 2 Commonwealth Agricultural Bureaus, Farnham Royal, Bucks, England.

7. Smith, E., L. C. Chadwich, and K. Reisch. 1966. The use of antidessicants in reducing transpiration and protecting ornamental plants against winter injury. Proc. Amer. Soc. Hort. Sci. 88:703-707.

8. Van Bavel, C. H. M., F. S. Nakayama, and W. L. Ehrler. 1965. Measuring transpiration resistance of leaves. Plant Physiol. 40(3):535-540.

VEGETABLE AND OTHER

Placement of Phosphorus for Tomatoes

Billy W. Hipp[1]

Abstract: Studies involving rate and placement of phosphorus were conducted on a clay soil. The results indicated that broadcast P is not effective in obtaining early growth and maximum yield of tomatoes. For maximum benefit on tomatoes, phosphorus should be placed directly beneath the seed at a depth of 2 to 4 inches.

Tomato seedlings growing in the Rio Grande Valley are often purple in color and growth is at a very slow rate. This is particularly true for tomatoes planted very early when soils are still cold and especially on heavy clay soils. Purple coloration and stunting effects are characteristics of phosphorus deficiency (3). These symptoms often occur on clay soils that have been fertilized with phosphorus.

To evaluate the placement and rate of P fertilizer on field grown tomatoes, field experiments were conducted on Harlingen clay soil in the spring of 1967.

MATERIALS AND METHODS

The experimental site was approximately 1½ mile north of Progreso, Texas. The soil in the area is Harlingen clay with the chemical characteristics shown in Table 1. The soil of the area is typified by slow water penetration, slow oxygen diffusion and restricted root growth. The clay content of this soil is about 60% with montmorillonite the dominant clay mineral.

Preplant applications of broadcast and placed phosphorus treatments at rates of 40, 80, 120, 200 and 400 lbs. of P_2O_5 per acre were applied. A check treatment was also included. The placed treatments were applied with a chisel directly under the seed row to a depth of about 3 inches. The broadcast treatments were spread uniformly over the entire plot and mixed into the surface 3 inches with a rolling cultivator. The source of P_2O_5 was 0-46-0. Plots were 45 ft. long and 19 ft. wide. The treatments were replicated four times. Chico tomatoes were planted on 76" centers (3 row plots) and watered up on February 16, 1967. Normal cultural practices for the area were followed throughout the growing season. Growth rate of the tomatoes was determined by taking and weighing plant samples from the plots at various time intervals. Rate of maturity was also observed by recording the days required until 10% of the plants in a plot had one or more blooms. Yield data were obtained by harvesting one row per plot.

---

[1] Assistant Professor, Texas A&M University, Texas Agricultural Experiment Station, Lower Rio Grande Valley Research and Extension Center, Weslaco.

RESULTS AND DISCUSSION

There was a visual response to the placed P treatments throughout the experimental period beginning the first week after the plants emerged. There was little visual phosphorus response from the broadcast treatments. The relative size of plants due to treatment at 25 days after planting and 49 days after planting are shown in Table 2. After 25 days the growth from the highest broadcast treatment, 400 lbs. of phosphorus, was equivalent to growth from about 50 lbs. P_2O_5 placed below the seed. Maximum plant growth 25 days after planting was from an application of 120 lbs. of phosphorus placed below the seed. After 49 days the maximum growth was obtained from 200 lbs. of phosphorus placed below the seed while the growth of plants which were treated with 400 lbs. of broadcast phosphorus was equivalent to growth rate from plants treated with 25 lbs. of placed phosphorus. The plots with no P as well as the broadcast treatments had stunted, purple plants typical of P deficiency. After about 7 weeks the plants were no longer purple in color but these plants never "caught up" with the plants that were not P deficient.

Table 2 also shows the time required for the plants to reach the bloom stage. Plants treated with 40 lbs. of P_2O_5/acre had a faster growth rate and bloomed 11 days prior to the check plots. Rates of placed P in excess of 40 lbs. resulted in only 3 days earlier blooming than the 40 lb. rate. Plants grown where 400 pounds per acre of phosphorus was broadcast bloomed 9 days earlier than the check but plants grown where 40 lbs. of phosphorus was broadcast bloomed only 1 day earlier than the check.

The early bloom carried over into the yield period. The cumulative yields of plots for the second and third harvest are shown in Figure 1. Maximum yields at all three harvests were obtained from tomatoes grown where 200 lbs. of phosphorus was placed. The broadcast treatments increased the yields only slightly over the check while 200 lbs. of P_2O_5 placed increased yields about 2 times.

A suggested value for adequate soil P by $NaHCO_3$ extract has been given as 18 to 25 ppm P (1). The high P requirements of tomatoes coupled with poor root growth in clay soils, however, results in the need for a higher concentration of P than is required for many crops. The

Table 1. Chemical Characteristics of the Harlingen Clay Soil Used in the Study.

ppm P extractable with		*Exchangeable cations meq/100 g soil*			
0.5 M $NaHCO_3$ at pH 8.5	*Acidified ammonium acetate at pH 4.2*	*K*	*Ca*	*Mg*	*Na*
23	65	1.4	34.0	9.0	3.5

pH of saturated soil paste was 8.3

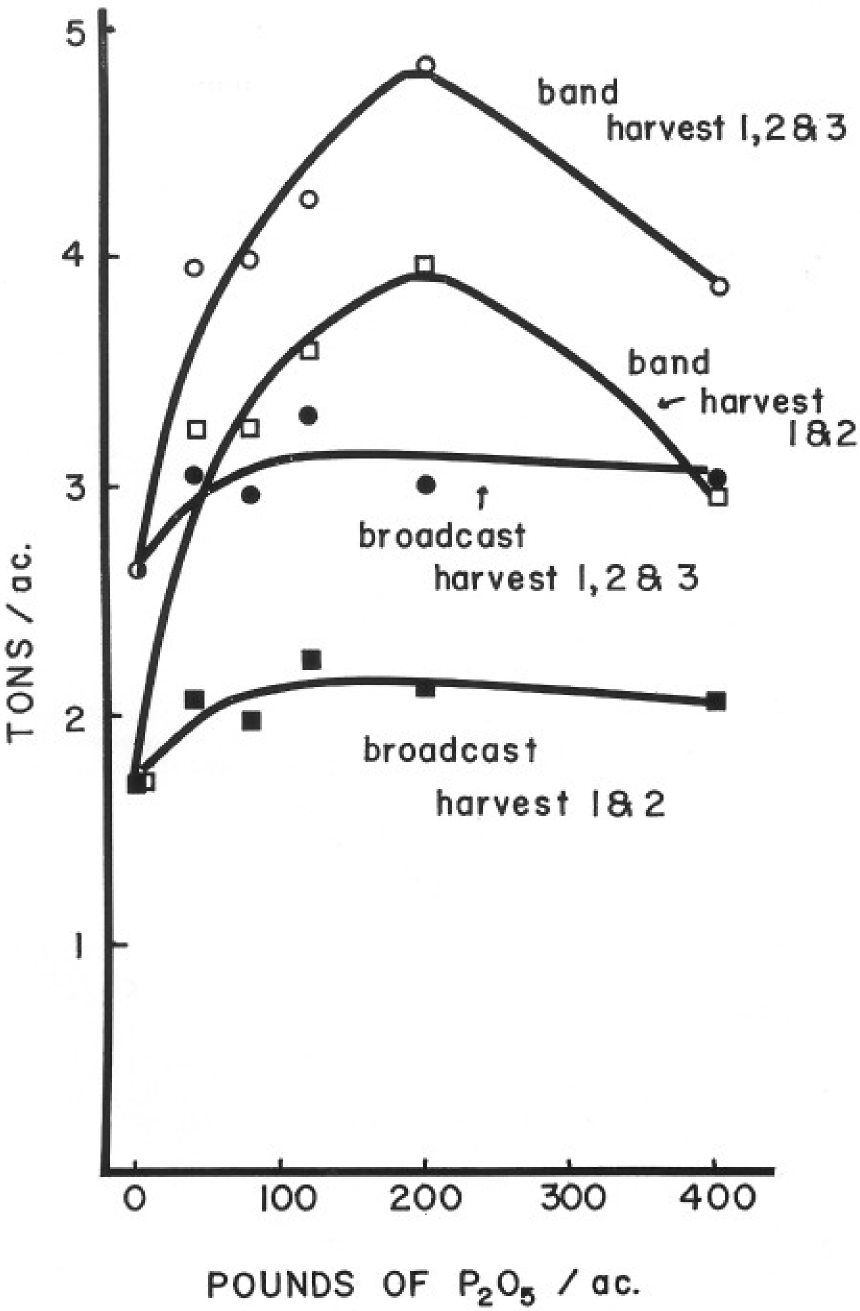


Figure 1. Influence of rate and placement of phosphorus on tomato yields.

Table 2. Influence of Phosphorus on Growth and Maturity of Chico Tomatoes.

Treatment	*Grams per plant (green)*		*Days from planting*
lbs. P_2O_5/Acre	*25 days*	*49 days*	*until bloom*
0	0.120	4.0	63
40 band	0.160	22.5	52
80 band	0.205	24.0	51
120 band	0.260	28.0	50
200 band	0.230	29.0	50
400 band	0.230	24.5	49
40 broadcast	0.125	7.0	62
80 broadcast	0.175	7.0	57
120 broadcast	0.145	6.5	57
200 broadcast	0.170	8.5	55
400 broadcast	0.185	10.0	54

fact that young tomato roots grow down rather than laterally has generally resulted in better response to P placed directly beneath the seed than when placed to the side (2). Placement directly below the seed was improtant in this experiment because erratic and reduced plant growth was obtained if the seed was not planted directly over the band of phosphorus.

Results from this experiment indicate that P should be placed directly beneath the seed for maximum growth and yield of tomatoes. The recommended depth of placement is 2 to 4 inches below the seed.

LITERATURE CITED

1. Jackson, M. L. 1958. Soil Chemical Analysis. Prentice Hall, Inc. Englewood Cliffs, N. J.

2. Nelson, W. L. and C. M. Hansen. 1968. Methods and Frequency of Fertilizer Application. *In* Changing Patterns in Fertilizer Use. L. B. Nelson Ed. Published by Soil Sci. Soc. of America.

3. Skinner, J. J. and E. R. Purvis. 1949. Plant Nutrient Deficiencies in Vegetable or Truck Crops. *In* Hunger Signs in Crops. Published by American Society of Agronomy and National Fertilizer Association.

Developmental Anatomy of the Irish Potato (*Solanum Tuberosum*) During Root and Stolon Differentiation

Joe M. Ernst, Bruce A. Perry, and H. T. Blackhurst[1]

Abstract: The anatomy of the main axis at all levels of the underground portion of the potato is that of a stem. Young roots were studied prior to their emergence through the cortex. Roots arising at all levels of the main axis originated from the external phloem parenchyma. All roots arising from the main axis are adventitious roots. This is not in conformity with all of the literature reviewed. The anatomy of the stolon resembles the anatomy of the main axis. Roots arising from stolons are identical to those arising from the main axis and should thus be termed adventitious roots.

INTRODUCTION

Although a great deal of work has been done on nutritive responses, disease resistance, and tuber development of the potato, comparatively limited investigations have been made to clarify the anatomy of the underground portion of the plant.

The main underground axis has a stem anatomy that is similar to that of the stolon (1, 7).

There is difference of opinion as to whether the roots located at the base of the sprout should be termed true roots (3,6). This term has been applied to roots located at the base of the sprout. The roots near the soil surface are termed adventitious roots (1, 3, 6). There are also roots attached to the tuber-bearing stolons, which have been given no specific name.

If the 2 terms, adventitious roots and true roots, are necessary, there must be an anatomical difference on which to base the terminology.

The 2 regions studied were: those roots arising on the main axis immediately below the surface of the soil medium (upper roots) and those roots arising on the main axis immediately above the tuber piece (lower roots).

MATERIALS AND METHODS

'Norgold Russet' and 'Red La Soda' were the varieties used in this study. Tuber pieces were selected within a weight range of 1.5 to 2.5

[1] Graduate Student, Professor of Horticulture, and Professor of Horticulture respectively, Soil and Crop Science Department, Texas A&M University, College Station, Texas.

oz. The tubers were planted at 5-inch depths in 10-inch plastic pots. The 2 types of media used were: a 1 to 1 mixture of horticultural grade perlite and sphagnum peat moss by volume, and ¼ inch gravel. These media were chosen to minimize damage to the roots when sampling stolons. All plants received a complete fertilizer solution daily.

Sprouts for study were collected at ¼, ½, 1, 1½, 2, 2½, 3, and 4 inches. These sprouts were killed and fixed in formalin-acetic-alcohol (8). Developing roots and stolons were also collected and preserved. The tissues were prepared according to standard procedures for tertiary butyl alcohol dehydration, Tissuemat embedding, and safranin and fast green staining (4, 5, 8).

RESULTS AND DISCUSSION

Upper and lower roots: A cross section of the base of the main axis is pictured in Fig. 1 and 2. This section was selected from a position immediately below the shoot apical meristem. The entire sprout did not exceed ½ inch in length. Anatomy of the upper root is comparable to that of the lower root. The section studied was selected from the tip of a 3-inch sprout prior to its emergence above the medium.

Fig. 1 shows the basic stem anatomy of the main axis which was observed in both the upper and lower regions. Two lateral roots (R1 and R2) are differentiating adjacent to a developing stolon. Root R2 in Fig. 1 represents a median section.

Fig. 1 and 2 are the basis for determining which terminology should be used for the lower root. Adventitious, as defined by Esau (2) refers to "a structure arising not in its usual place," and adventitious roots are "roots arising from stems, or leaves, or old parts of a root." The origin of the lower root is seen by observing the location of the cambial region in Fig. 2CR. Fig. 2 shows that the lower root arises outside the cambial region in the external phloem parenchyma. This origin is identical in the upper root. The lower root exhibits the vascular arrangement characteristic of a root.

By the definition of an adventitious root previously stated (2) and the evidence presented, both the lower root and upper root should be termed adventitious roots. This terminology is not in conformity with some authors (6). It was their belief that the lower roots should be termed true roots.

Stolons have been described in the literature reviewed as "root stolons, underground stems, modified stems, stems, and rhizomes" (3, 6). No anatomical variation could be found between stolons selected from the upper, middle, and lower regions of the main axis. Fig. 1 shows the apical meristem of the stolon which resembles that of the main axis as described by Artschwager (1).

No specific name has been applied to roots arising from stolons. When comparing the roots arising from stolons, to roots arising from the

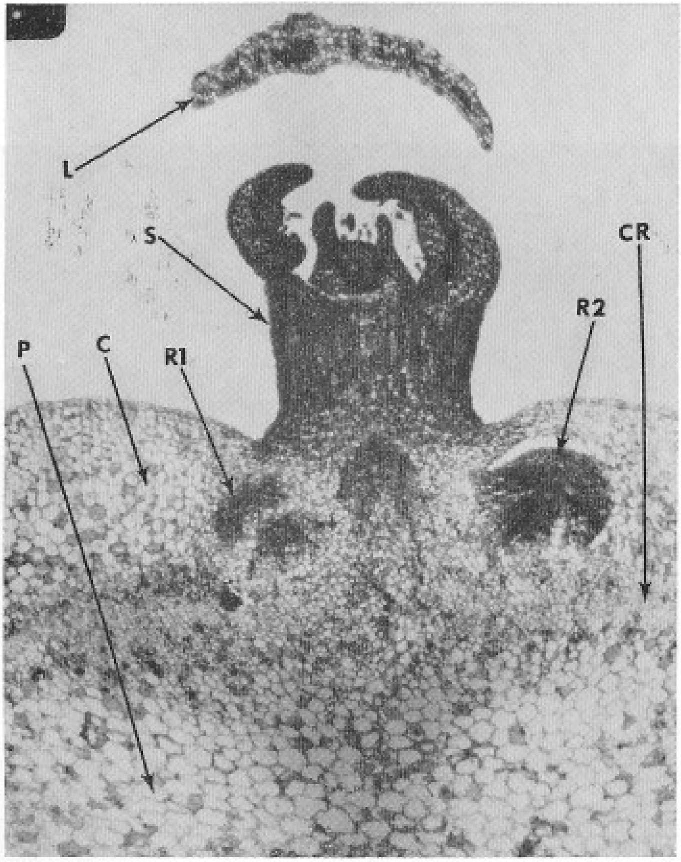


Figure 1. Potato "root"; main axis in cross section (36X). C, cortex. CR, cambial region. L, leaf. P, pith. R1, R2, developing lower roots. S, stolon.

main axis, it was observed that, in both cases, the origin of the root was in the region exterior to the vascular cambium. Because both roots originate from stem tissue they should be termed adventitious roots.

LITERATURE CITED

1. Artschwager, Ernst. 1924. Studies on the potato tuber. *J. of Agr. Res.* 27:809-835.

2. Esau, Katherine. 1961. Anatomy of seed plants. John Wiley & Sons, Inc., New York.

3. Hayward, Herman E. 1938. The structure of economic plants. The Macmillan Company, New York.

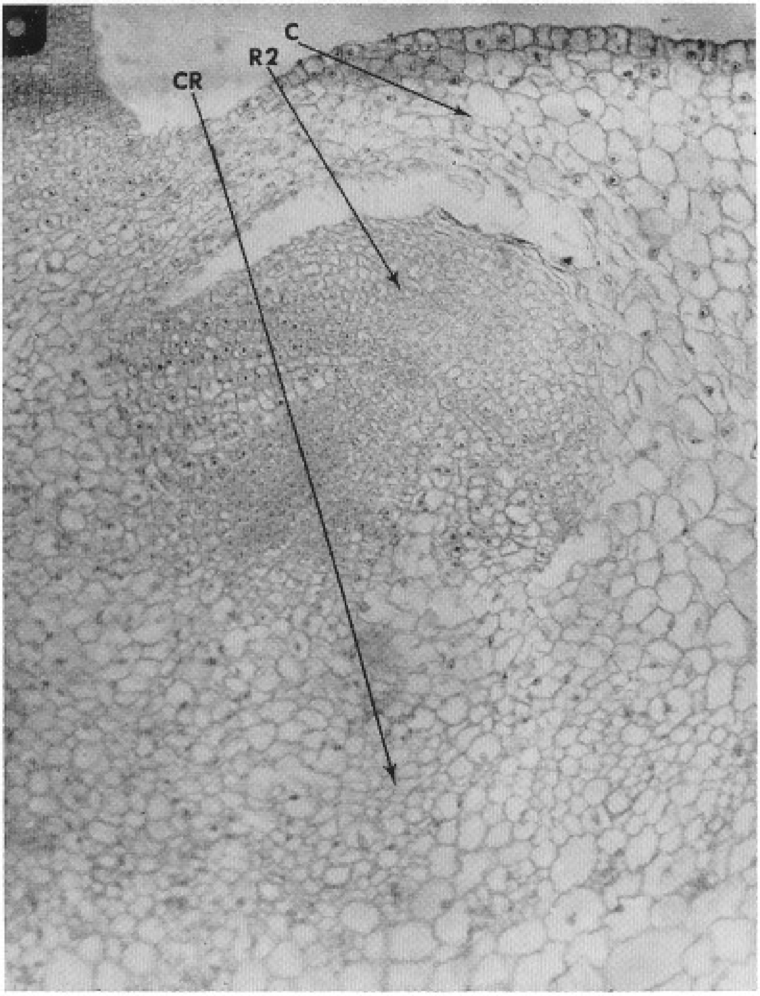


Figure 2. Potato root; magnification of the lower root in Fig. 1, R2 (108X). C, cortex. CR, cambial region.

4. Jensen, William A. 1962. Botanical histochemistry. W. H. Freeman Co., San Francisco, California.

5. Johansen, D. A. 1940. Plant microtechnique. McGraw-Hill Book Company, New York.

6. Kehr, August E., Robert V. Akeley, and Geoffrey V. V. Houghland. 1964. Commercial potato production. *U.S. Dept. Agr. Agr. Handbk.* 267.

7. Plaisted, Philip H. 1957. The growth of the potato tuber. *Plant Physiol.* 32:445-453.

8. Sass, John E. 1958. Botanical microtechnique. The Iowa State College Press, Ames, Iowa. 228 pp.

Nitrogen Increases Bell Pepper Susceptibility to Bacterial Soft Rot[1]

James R. Thomas[2]

Abstract: The effect of nitrogen concentration in the fruit and stem on the susceptibility of sweet peppers to infection by bacterial soft rot was investigated, using fruit produced on plants to which up to 200 pounds per acre elemental nitrogen had been applied. Infection increased from 25 to 50% as the nitrogen content of the fruit stem increased from 3 to 4%. The hot water immersion treatment was less effective in controlling decay in nitrogen-rich fruit than in the nonfertilized fruit, but did not decrease infection more than 20% in any case.

Bacterial soft rot is the most destructive postharvest decay of bell peppers. Bacteria responsible for this disease are commonly present in most soils and normally invade the harvested pods through the stem tissue. Infection may occur in the field or in contaminated picking and packing equipment (3).

Losses from bacterial soft rot are usually more severe if the peppers are harvested following a period of rainy weather. Johnson (3) observed that susceptibility to soft rot infection varied between seasons and also between specific fields of peppers in the same season. Analysis of field operation and weather data suggested that the nitrogen fertilization program and/or the irrigation regime might be involved.

The purpose of the research reported here was to determine the effects of nitrogen fertilization and irrigation regimes on the nitrogen and moisture contents of the bell pepper fruit and fruit stem and to investigate the relationship between moisture and nitrogen contents of the pepper fruit and its susceptibility to bacterial soft rot.

METHODS AND MATERIALS

The experiment was conducted on Hidalgo sandy clay loam soil at the Soil and Water Conservation Research Farm, Weslaco, Texas.

Sweet bell peppers, Yolo Wonder variety, were planted in double rows on beds 38 inches apart in September 1965. The field was treated uniformly for the first two months. The peppers were irrigated as needed

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

[2] Research Soil Scientist, USDA, Weslaco, Texas.

and received 14.7 inches of rainfall from September through December. The irrigation regimes which formed the main plots were initiated in December and were established in areas 9 double rows wide by 100 ft. long. The moisture treatments designated M_1, M_2, and M_3 were irrigated when the average moisture content of the 2 feet of soil approached 60, 40, and 20% available water, respectively. The M_1 (wet) treatment was irrigated three times between December 20 and January 22. The medium moisture treatment (M_2) received one irrigation during this period, whereas the dry moisture treatment (M_3) was not irrigated after the establishment of the plants. The subplots (3 double rows by 100 ft.) received 0, 100, and 200 pounds of nitrogen per acre as ammonium nitrate on November 26. The fertilizer was placed at a depth of 4 to 6 inches in the bed between the double rows of peppers at flowering. A randomized split plot design with four replications was used.

Access tubes for soil water measurements by neutron scattering were installed to a depth of 4 feet in two locations in each main plot.

Leaf, pod, and fruit stem samples were collected several times during the season and analyzed for total nitrogen (1) and nitrate (2). The moisture content of the fruit samples (pod and stem tissues) was also determined. However, as the nitrogen fertilizer and irrigation treatments did not significantly affect the moisture content of the plant tissues, the moisture values are not reported. Other fruit samples were inoculated with bacterial soft rot. Susceptibility was based on (a) percent infection after artificial inoculation and incubation for 6 days at 70°F, and (b) percent infection 6 days after inoculation when immersed in hot water (128°F for 1½ minutes) 18 hours after inoculation. The percent infection after an 18-hour incubation period was also recorded. A total of 360 pods was used in each test. The fruit was harvested weekly until the plants were killed by freezing temperatures.

RESULTS AND DISCUSSION

Sweet pepper fruit yields increased with the application of nitrogen fertilizer and with an increase in frequency of irrigation (Table 1). However, the 268-pound-per-acre difference in yields between the wet (M_1) and dry (M_3) moisture treatments was not significant. The low yields were possibly due to climatic factors and a late crop.

Applications of nitrogen significantly increased the total nitrogen content of the leaves (Table 2). The nitrogen concentration changed throughout the growing season. Uptake of nitrogen from the fertilizer was apparent on December 1, 5 days after application. Visual nitrogen deficiency symptoms were first observed on December 13, during a period of heavy fruiting, on plants not receiving fertilizer. Based on findings by Thomas and Heilman (4) that the leaf tissue nitrogen content at the initiation of flowering should be approximately 5%, the leaf tissue nitrogen values indicate that the plants were not adequately supplied with nitrogen. Failure of the 200-pound nitrogen addition to significantly increase the nitrogen content above that obtained with the 100-pound-per-acre rate suggests that factors other than nitrogen supply were affecting nitrogen uptake. Applications of phosphorus fertilizer to Hidalgo sandy clay loam have been shown to increase nitrogen uptake (5). Irrigation treatments had no significant effect on the nitrogen content of the leaf.

The nitrogen additions significantly increased the total and nitrate nitrogen content of the pods and fruit stems (Table 3). Because the causal bacteria responsible for soft rot invade the harvested pods through the broken stem tissue, the nitrogen content of the stem may be more important in establishing the decay-producing bacteria. Figure 1 indicates that the percentage infection after 18 hours of incubation was closely related to the nitrogen content of the stem.

Susceptibility of the pods to infection by bacterial soft rot was significantly increased by application of nitrogen (Table 4). The effective-

Table 1. Green pepper yields as affected by nitrogen fertilization and irrigation regime.

Nitrogen applied	Irrigation regime M_1	M_2	M_3	*Nitrogen mean*
		Lb./acre		
0	5275	5275	4851	5134 a*
100	6144	5185	5836	5721 b
200	5934	6302	5861	6032 c
Moisture mean	5784 a	5587 a	5516 a	
C.V. = 11.4%				

* Values in same row or column followed by same letter not significantly different at 5% probability level by Duncan's multiple range test.

Table 2. Effect of nitrogen fertilization on total nitrogen content of pepper leaves at various times during the season.

Nitrogen applied	*Dec. 1*	*Dec. 10*	*Dec. 22*	*Jan. 7*
Lb./acre			Percent	
0	4.00 a *	4.29 a	3.76 a	3.28 a
100	4.88 b	5.52 b	4.42 b	3.94 b
200	4.79 b	5.48 b	4.42 b	4.09 b
C.V. (%) =	4.8	7.3	5.8	2.9

* Values in same column followed by same letters not significantly different at 5% probability level by Duncan's multiple range test.

Table 3. Effect of nitrogen fertilizer on total and nitrate-N content of pepper pods and fruit petioles at various times during season.

Nitrogen applied	*Pods*					*Fruit Petioles*					
	Jan. 3	*Jan. 10*		*Jan. 28*		*Jan. 3*		*Jan. 10*		*Jan. 28*	
	N	*N*	*NO_3-N*	*N*	*NO_3-N*	*N*	*NO_3-N*	*N*	*NO_3-N*	*N*	*NO_3-N*
Lb./acre	%	%	ppm	%	ppm	%	ppm	%	ppm	%	ppm
0	2.58 a *	2.22 a	462 a	2.30 a	624 a	3.22 a *	2190 a	3.30 a	3821 a	3.12 a	3040 a
100	2.89 ab	2.60 b	872 b	2.59 b	821 b	4.21 b	3952 b	4.35 b	8004 b	3.16 b	5442 b
200	3.09 b	2.67 b	842 b	2.68 b	883 b	4.37 b	4217 b	4.51 b	7902 b	4.11 c	6412 c
C.V. (%) =	1.4	6.5	19.0	5.9	11.1	7.4	13.7	7.1	20.5	9.1	18.9

* Values in same column followed by same letter not significantly different at 5% probability level by Duncan's multiple range test.

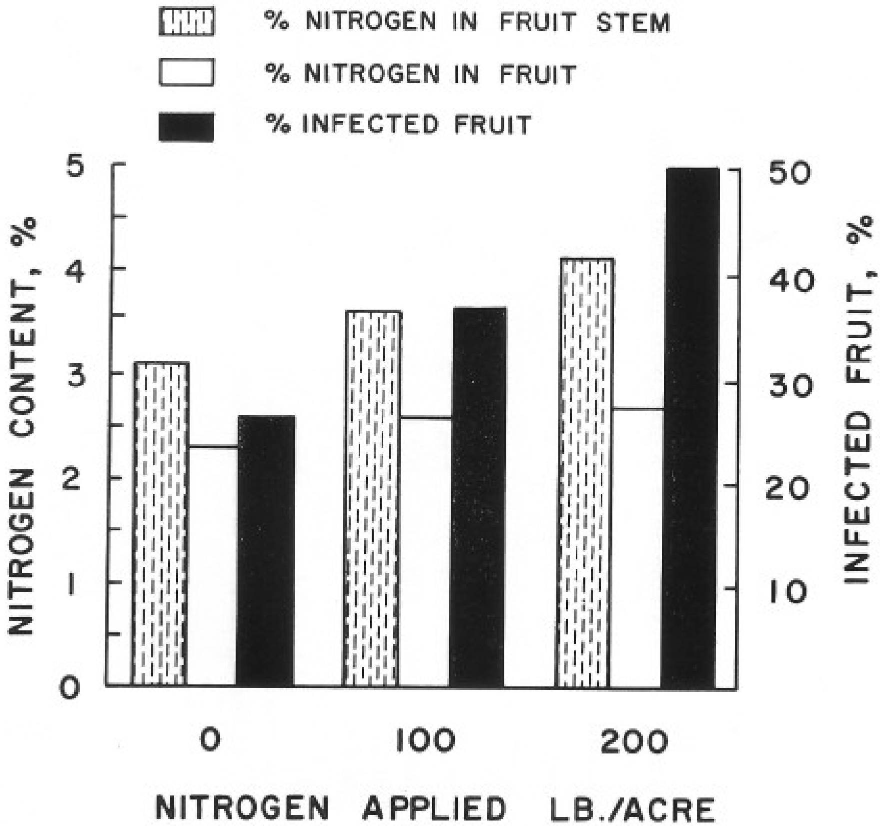


Figure 1. Effect of nitrogen fertilizer on the nitrogen content of pepper fruit and stem and percentage of fruit infected by bacterial soft rot.

Table 4. Effect of nitrogen fertilization on the percentage infection of sweet pepper fruit by bacterial soft rot.

Nitrogen applied	*Susceptibility after* *Inoculation*	*Inoculation plus hot water treatment*
Lb./acre	— — — — — — — Percent	— — — — — — —
0	66.7 a *	45.8 a
100	65.8 a	66.7 b
200	74.2 b	62.5 b
C. V. (%) =	43.1	28.1

* Values in same column followed by same letter not significantly different at 5% probability level by Duncan's multiple range test.

ness of the hot water immersion treatment in controlling infection decreased as the nitrogen content of the fruit increased.

Nitrogen fertilizer is commonly applied after the first or second fruit harvest to insure continued vegetative growth. This practice undoubtedly increases the nitrogen content of the immature fruit and pod stems. Young developing fruit is known to mobilize nitrogen. Thomas and Heilman (4) observed that the nitrogen content of sweet pepper leaves decreased markedly with the onset of fruiting. Fruit harvested a few days after the nitrogen application would be especially susceptible to infection by bacterial soft rot.

As nitrogen fertilization increases both yields and the susceptibility of peppers to bacterial soft rot, the most profitable rate of nitrogen application is not necessarily the one that results in maximum yields. Part of the risk from soft rot can be reduced by applying the bulk of the nitrogen fertilizer early in the season and using plant tissue tests to obtain information as to the need for later applications.

LITERATURE CITED

1. Association of Official Agricultural Chemist (u. e.) Official Methods of Analysis, Washington, D. C. (6th Ed.,) p. 27. 1945.
2. Johnson, C. M. and A. Ulrich. 1950. Determination of nitrate in plant material. Anal. Chem. 22:1526-29.
3. Johnson, H. B. 1966. Bacterial soft rot in bell peppers: causes and commercial control. U. S. Dept. Agr., MRR. 738, 6 pp.
4. Thomas, James R. and Marvin D. Heilman. 1964. Nitrogen and phosphorus content of leaf tissue in relation to sweet pepper yields. Proc. Amer. Soc. Hort. Sci. 85:419-425.
5. Thomas, James R. and Marvin D. Heilman. 1967. Influence of moisture and fertilizer on growth and N and P uptake by sweet pepper. Agron. Jour. 59:27-30.

Effects of Methods of Placement on Performance of Trifluralin, CDEC, and DCPA Applied to Soil[1]

R. M. Menges and J. L. Hubbard[2]

Abstract: Soil-incorporated applications and subsurface applications of herbicides were compared in the glasshouse under simulated furrow irrigation. Soil temperatures ranged from 75 to 102 F during the first 3 weeks and soil moisture remained near field capacity for more than 1 week.

Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA)[3] and *a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine (trifluralin)[4] performed best when applications were incorporated with the surface ½ inch of the Hidalgo sandy clay loam. Deeper incorporation to 3 inches resulted in poorer performance with both herbicides as did the soil surface applications with trifluralin. Performances were poor with all sub-surface applications of DCPA and trifluralin. Soil profiles showed that redroot pigweed (*Amaranthus retroflexus* L.) and barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) grew rapidly through the subsurface layers of DCPA, and lateral root growth was restricted only in these narrow herbicidal zones in soil.

CDEC (2-chloroallyl diethyldithiocarbamate)[5] performed best at the ½-inch depth in soil and subsurface applications were superior only in barnyardgrass control. Performances of subsurface applications decreased more rapidly with increasing depths.

INTRODUCTION

In an unpublished experiment here in 1958, applications of two thiocarbamate herbicides were more efficient when applied subsurface than when applied on the soil surface[6]. Costel (1) reported effective chemical weed control in sugar beets with applications 1 inch below the surface. Foy, et al. (3) reported more efficient weed control but less selectivity in corn when herbicides were applied subsurface rather than incorporated 3 inches in soil. Hauser and Parham (4) reported that certain thiocarbamate herbicides were more efficient when applied subsurface 1½ inches than when incorporated with soil. Conversely, Knake, et al (5) found no benefit of subsurface applications of herbicides for control of green foxtail (*Setaria viridis* (L.) Beauv.).

The primary objectives of the experiment were to study (1) the

---

[1] The work is part of a cooperative project of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and the Texas Agricultural Experiment Station, Weslaco, Texas.

[2] Research Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and Agronomist, Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas, respectively.

[3] DCPA formulated as Dacthal furnished gratis by Diamond Alkali Co.

[4] Trifluralin formulated as Treflan furnished gratis by Eli Lilly and Co.

[5] CDEC formulated as Vegedex furnished gratis by Monsanto Co.

[6] R. M. Menges, 1958 Annual Report pp 28-33, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

comparative activities of soil-incorporated and sub-surface applications of herbicides on simulated furrow-irrigated soil, (2) the effect of depth of application on the effectiveness of the two methods of treatment, and (3) the influence of soil moisture and temperature on herbicidal activity.

MATERIALS AND METHODS

Redroot pigweed (*Amaranthus retroflexus* L.) and barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) seeds were incorporated with a Hidalgo sandy clay loam previously air-dried and passed through a ⅛-inch screen[7]. Galvanized metal flats, 12 inches long by 8 inches wide by 3⅓ inches deep with perforated sides and bottoms, were (a) filled with soil using kraft paper as dividers at the ½-, 1½- or 3-inch depths or were (b) filled only to the ½-, 1½-, or 3-inch depths. Incorporated applications of herbicides were sprayed on the surface of filled flats August 10, 1966. They were left undisturbed or were immediately incorporated with the surface ½-, 1½-, or 3-inch depths by removing the soil above the preset paper, mixing in glass containers, and then returning the mixed soil to the assigned flats. Subsurface treatments were applied by spraying the soil surface at the ½-, 1½-, or 3-inch depths and then immediately filling the flats with untreated soil.

Blotter papers were placed around the inside edges of all flats during spraying to avoid spray runoff and resulting increased herbicidal concentrations.

Flats were then placed on jute pads in irrigation pans. The pans were ¾-filled with salt-free water which entered only the sides of the flats to simulate furrow irrigation. The initial irrigation was completed 3 hours after treatment. Flats were placed in a glasshouse and were irrigated every 4 to 7 days thereafter. Treatments were replicated four times in a split-plot design with herbicide treatments assigned to main plots and methods of application to subplots. Each subplot consisted of one flat.

Gravimetric determinations of moisture were made periodically in the surface 2 inches of soil and temperatures were recorded continually at ¼- and 2-inch depths. Soil samples were taken for moisture determinations just before each irrigation to indicate soil moisture losses.

The effects of application method on herbicidal performance were evaluated 2 weeks after treatment by weed control ratings (0 = no control, 10 = complete control). The average rating in each herbicidal treatment for each application method was individually compared with that of the corresponding check. Data are reported as percent control.

[7] Hidalgo sandy clay loam contained 65% sand, 22% clay, and 13% silt; 1.5% organic matter, 7.8 pH, 19% water at field capacity, and 21.6 meq/100 g cation exchange capacity.

RESULTS AND DISCUSSION

CDEC (2-chloroallyl diethyldithiocarbamate) was most efficient when applied subsurface at the ½-inch depth (Fig. 1). The ½-inch incorporated applications of the herbicide were equally efficient in broadleaf weed control but were inferior in grass control. Soil surface applications and those below ½ inch were relatively ineffective. The performance of subsurface applications decreased more markedly with increasing depths beyond ½ inch.

The data do not, however, support the development of subsurface applications of CDEC for selective weed control in vegetable and other cultivated crops in the Southwest. Although preemergence soil surface applications of CDEC are recommended for weed control in cucurbits, lettuce, and spinach, these crops will be injured if the herbicide penetrates the soil to the vegetable seed depth (6, 7). A small error in the depth of application of subsurface treatments will not only markedly reduce the control of weeds but may well increase crop injury because of increased concentrations of herbicide in the crop seed zone in soil.

Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) performed most efficiently when incorporated ½ inch. Surface applications were nearly as effective, however, and the data explain the satisfactory commercial field performances with DCPA on furrow-irrigated soils without incorporation or with shallow incorporation by rollers and cultipackers. Study of ultra-shallow incorporation of herbicides with soil may reveal additional selectivity in sensitive crops. Performance of the herbicide decreased with increasing depths of incorporation below ½ inch. Subsurface applications performed very poorly.

Trifluralin (*a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine) performed best when incorporated ½ inch. Deeper incorporated applications, surface applications, and subsurface applications performed poorly.

Examination of the soil profiles showed that weed roots penetrated the subsurface applications of DCPA and grew vigorously below the treated zone in soil (Fig. 2), resulting in poor weed control. Note the absence of lateral roots in the narrow subsurface zone of herbicide. Only rudimentary root growth existed in plots where herbicides severely stunted the growth of shoots.

Mean soil temperatures ranged from 75 to 102 F during the first 3 weeks after treatment with little temperature differential in soil depths (Table 1). Soil moisture remained near field capacity for more than 8 days; only the surface ¼ inch was dried during the second and third weeks (Table 2). Results suggest that changes in soil temperature and moisture may alter the performance of these herbicidal treatments under field conditions. Subsurface-applied herbicides may perform better when soil temperatures are reduced because weed roots grow more slowly and may remain in the treated zone a sufficient time to succumb.

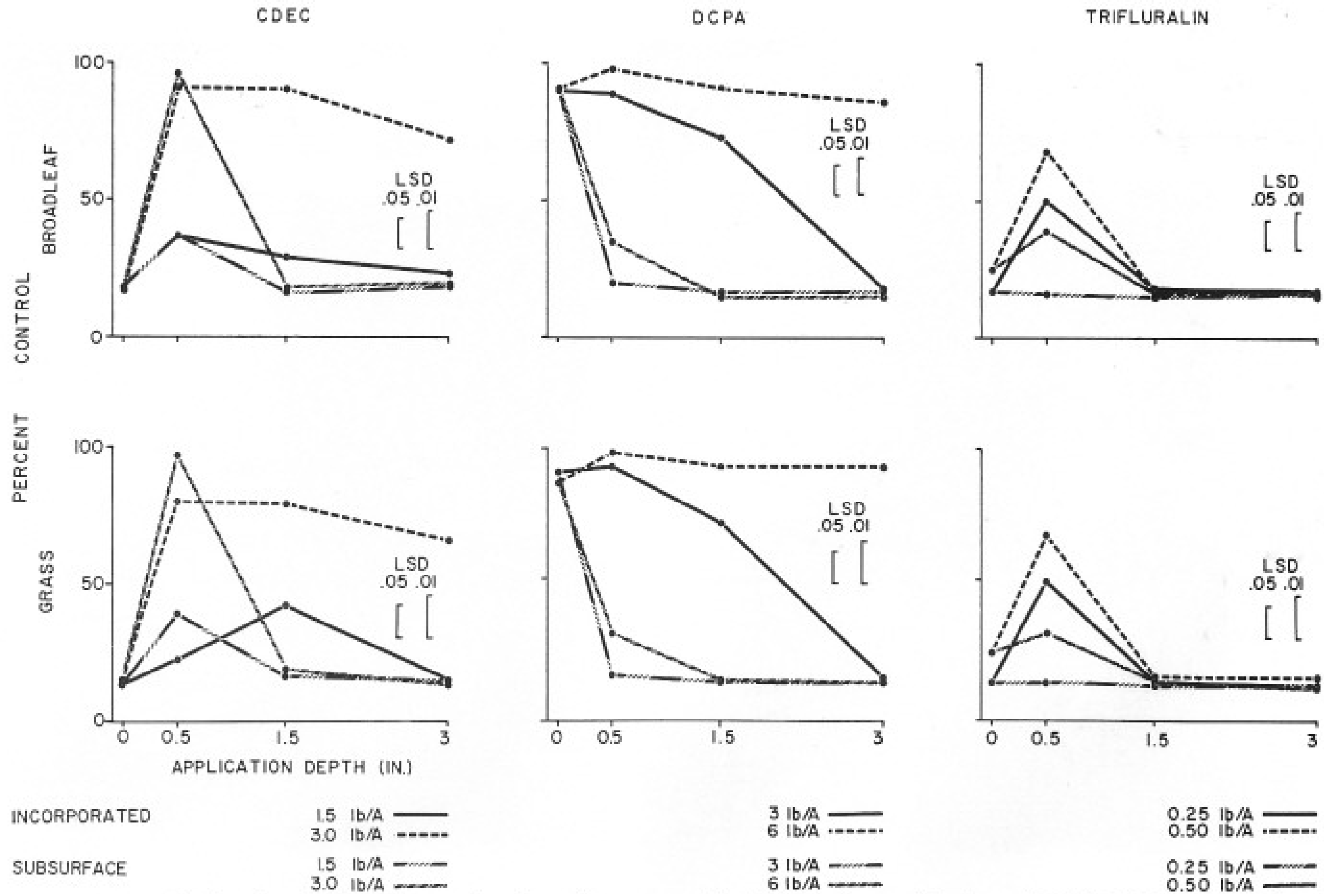
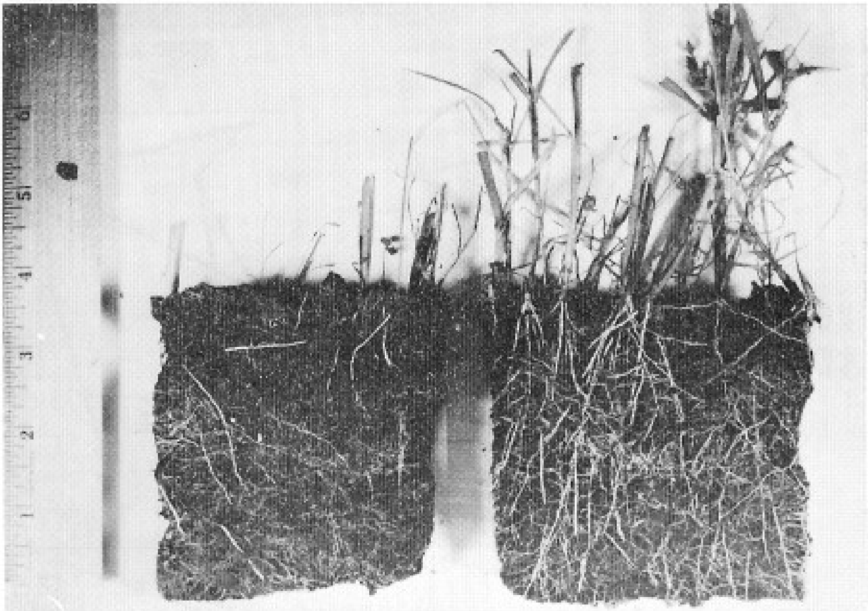


Figure 1. Broadleaf and grass weed control with soil-incorporated and subsurface applications of CDEC, DCPA, and trifluralin.



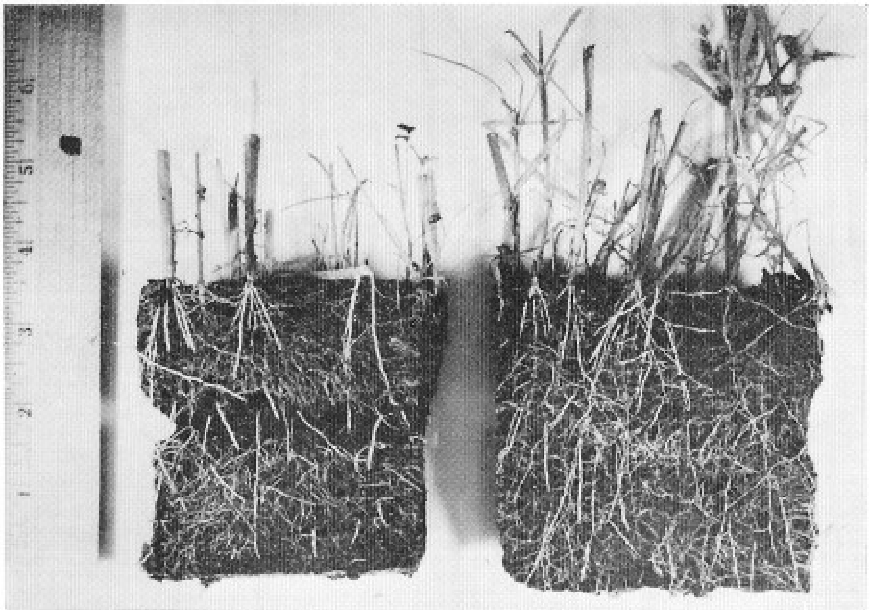


Figure 2. Soil profiles of DCPA (6 lb/A) applied subsurface ½-inch (upper photo) and 1½-inch (lower photo). Treated soils are shown in the left-hand and untreated soils in the right-hand portion of each photo.

Several investigators (6, 7, 8, 9, 10) have reported increased selectivity in crops with herbicides incorporated shallowly in soil. Crowell (2) found stunting in beets where a carbamate herbicide was applied subsurface 2 inches but none where incorporated. The present results are in agreement with the work of these scientists and offer an explanation for previously observed effects of herbicide placement in soil.

Table 1. Temperature (F) at the ¼- and 2-inch depths in a Hidalgo sandy clay loam during the first 3 weeks after soil-incorporated and subsurface herbicide applications in the glasshouse.[a] August 1966.

Weeks (no.) after treatment	*Soil depth (in.)*	*Mean temp.*		*Total hr above*				
		Max.	*Min.*	*70*	*80*	*90*	*100*	*110*
1	¼	101	76	168	107	55	29	—
	2	103	79	168	95	61	40	—
3	¼	101	75	504	273	145	62	—
	2	102	77	504	292	171	51	—

[a] Thermograph recordings.

Table 2. Moisture in the surface 2 inches of a Hidalgo sandy clay loam during the first 3 weeks after soil-incorporated and subsurface herbicide applications in the glasshouse. August 1966.

Soil depth (in.)	*Percent of field capacity[a]*				
	Days after treatment (no.)				
	0[b]	*5*	*8*	*14[b]*	*20[b]*
0 - ¼	9	202	106	44	34
½ - 1	—	177	119	74	74
2 - 3	—	182	124	82	71

[a] Field capacity = 20.1% water.
[b] Irrigation = 3, 14, and 20 days after treatment.

LITERATURE CITED

1. Costel, G. L. 1961. Equipment for the application of herbicides to sugar beets. Wyoming Agr. Ext. Sta. Mimeo Circ. 158.
2. Crowell, G. C. 1963. Field evaluation of selective herbicides in California sugar beets. WWCC Res. Prog. Rep.: 40-41.
3. Foy, C. L., T. Lyons, H. M. Kemper, and C. Koupke. 1963. Evaluation of soil incorporated herbicides for selective weed control in corn grown on Delta soil. WWCC Res. Prog. Rep.: 43-44.
4. Hauser, E. W., and S. A. Parham. 1965. Progress report: Subsurface application of thiocarbamate herbicides for weed control in peanuts (Abst.). SWC Proc. 18:115-116.

5. Knake, E. L., A. P. Appleby, and W. R. Furtick. 1967. Soil incorporation and site of uptake of preemergence herbicides. Weeds 15:228-232.

6. Menges, R. M., and J. L. Hubbard. 1965. Soil-surface and soil-incorporated applications of herbicides in furrow-irrigated spinach. Proc. Amer. Soc. Hort. Sci. 87:363-370.

7. ————————, and ————————. 1968. Influence of soil incorporation and climate on herbicides in cantaloupe. Proc. Amer. Soc. Hort. Sci. 92: (In press).

8. Mullendore, G. P. 1968. Cotton injury and weed control as affected by dual preemergence herbicide usage in the delta of Mississippi — 1967. SWC Proc. 21:358-365.

9. Oliver, L. R., and R. E. Frans. 1965. Influence of trifluralin rate and depth of incorporation on cotton and soybean lateral root development. SWC Proc. 18:85-91.

10. Upchurch, R. P., and F. L. Selman. 1968. Compatability of chemical and mechanical weed control methods. Weed Sci. 16:121-130.

Evaluating Damage to Ornamental Plants Caused by Climate Disasters

LEO L. BAILEY[1]

Abstract: Business and professional men recognize that a well landscaped place attracts customers and results in greater incomes. Property owners realize that a home well-planted makes for much more pleasant living and increases the value of property immeasurably in case of resale.

Extremes of flooding, drought, cold, and wind (hurricane or tornado) are examples of climate that may damage plants. Such plants may be insured and damages may be paid by the insurance company. Plants losses not replaced by insurance can definitely be used as an income tax deduction.

Deductible losses for insurance refunds or income tax reporting vary. Many factors help to evaluate an ornamental plant in a well landscaped situation. These factors determine the pre-disaster value of plants: (a) the type of plant and its special characteristics, (b) the height and spread of the plant and (c) the role of the plant in the general landscape plan. Once the pre-disaster value is determined, the loss ranging from 10 to 100 percent gives the deductible loss.

The horticulturist with his experience in growing and maintaining ornamental plants is qualified to do appraisals and evaluations. It is a service he can and must render.

No expenditure on a home or business increases the value of the property so quickly and easily as landscaping with trees, shrubs, and grasses. Trees in the forest may be valued at so much per board foot and this may make a large tree worth several dollars. But on the home grounds a tree that properly shades, frames and protects the home may be valued at several hundred or even thousands of dollars. There is no accurate way to estimate the value of a tree that fits effectively into a landscape plan.

The monetary value of ornamental plants has become more widely recognized. This is due in part to inflation which has caused all material possessions to seem more valuable. The high initial cost of ornamental plants plus the cost of maintenance and replacement have caused owners of homes and businesses to appreciate more fully good landscape design.

Business and professional men recognize that a well landscaped place attracts customers and results in greater incomes. Property owners realize that a home well-planted makes for much more pleasant living and increases the value of property immeasurably in case of resale. Resale is a common occurence today as the average family will move several times during its existence.

Climatic disasters as used in this context refers to extremes of

[1] Professor of Horticulture, Texas A&I University, Kingsville, Texas.

weather that occur periodically causing complete or partial loss to adapted ornamental plants.

Extremes of flooding, drought, cold, and wind (hurricane or cyclone) are examples of climate that may damage plants. Such plants may be insured and damages may be paid by the insurance company. Plant losses not replaced by insurance can often be used as an income tax deduction.

Last September severe Hurricane Beulah swept along the lower Gulf Coast of Texas causing widespread damage in the area served by our university. Home owners needing evaluation of plants losses became extremely numerous. So numerous in fact were the requests, that a scorecard was worked out through research and study. A sample copy of the scorecard as adapted to South Texas is shown in Table 1:

Table 1. Value of plants in landscaping homes and businesses.

	Value/Ft. Height	*$Value/Ft. Diameter Spread*
Acacia Farnesiana (Huisache)	4	3
Bauhinia purpurea (Purple Orchid)	5	3
Carya Pecan (Pecan)	10	6
Casuarina lepidophloia (Australian Pine)	3	3
Celtis laevisgata (Southern Hackberry)	4	4
Citrus paradisi (Grapefruit)	7	6
Cordia Boisseri (Anacahuita, Wild Olive)	10	8
Delonix regia (Royal Poinciana)	3	1
Ehretia anacua (Anaqua, Knock-Away)	6	4
Eucalyptus algeriensis (Eucalyptus)	2	3
Fraxinum Berlandierana (Rio Grande Ash)	5	4
Hibiscus Rosa-sinensis (Chinese Hibiscus)	2	1
Melia Azedarach (Chinaberry Tree)	4	3
Parkinsonia aculeata (Retama)	3	2
Rhoenix canariensis (Ornamental Date)	5	4
Pinus halepensis (Aleppo Pine)	10	3
Pithecolobium flexicaule (Texas Ebony)	6	6
Prosopis chilensis (Mesquite)	5	5
Prunus Persica (Peach)	4	4
Quercus virginiana (Liveoak)	6	6
Sapium sebiferum (Chinese Tallow Tree)	5	5
Washingtonia robusta	2	3

Scientific names of plants are specified to avoid confusion on common names. Trees and other plants are valued on height and spread. Values per foot are determined by a) rate of growth, b) density of leaves and branches, c) age of plant, d) life expectancy of plant, e) season for leaves, f) degree of adaptability, and g) general desirability as determined by local custom.

Trees ranged from as high as $10 per foot of height for the pecan to as little as $3 per foot of height for the Retama and Tepehuaje. Value per foot of diameter spread showed less variation.

SPECIAL PURPOSE PLANTS

Plants serving a special purpose in the overall landscape plan are given increased value. (Table 2). Trees shading and framing from the south and west are considered most valuable. Trees providing shade from east and southeast and those providing background for the picture created in landscaping are given an increased value of 10%. Trees supplying food for human consumption are given a special value of 10%. These values are too conservative in many instances but this is the problem always confronted when standardization is attempted.

PLANTS PARTIALLY DESTROYED

Ornamental plants are often completely uprooted, broken or otherwise destroyed so that a 100% loss is evident. In many other instances, however, the plant in question is only partially destroyed. One or more branches may be lost necessitating an evaluation based upon the percentage of the plant lost. This is largely a judgment factor but certain criteria can be helpful in arriving at a more accurate estimate. The appraiser considers these questions: (1) What proportion of the plant is actually destroyed? (2) How many years will be required for the plant to reach its pre-disaster value? The latter question is probably the most helpful.

A plant struck by climatic disaster may be still standing and still alive, but may be deemed a 100% loss if the damage is such that it can never fulfill its purpose in handscaping. It is easy to believe that a plant half destroyed is in reality completely destroyed. This varies, though, with the particular plant and its purpose. Some plants such as citrus fruits may lose the entire branch area but will in time make a complete recovery if the trunk, crown and roots are undamaged.

An appraisal system for plants partially destroyed is given in Table 3. Any plant requiring 10 years or more to reach its pre-disaster value is considered a 100% loss. A plant requiring 9 years to recover would be recorded as a 90% loss in an evaluation of deductible loss. This same system is carried out so that a 10% loss describes a plant that under normal conditions will reach pre-disaster value in one year.

Table 2. Increase value of plants serving special purposes.

Special Purpose Served	*% Increased Value*
Shade and Frame from South and West	20%
Shade and Frame from East and Southeast	10%
Located for Shade and Background	10%
Valued for Food Produced	10%
Ordinary Trees in Landscape	—

REPORTING DEDUCTIBLE LOSSES

Deductible losses for insurance refunds or income tax reporting vary as shown by the foregoing discussion. Many factors help to evaluate an ornamental plant in a well landscaped situation. These factors determine the pre-disaster value of plants: (a) the type of plant and its special characteristics, (b) the height and spread of the plant and (c) the role of the plant in the general landscape plan. Once the pre-disaster value is determined, the loss ranging from 10 to 100 per cent gives the deductible loss. Table 4 is a sample copy of a form used in reporting losses incurred to the Internal Revenue Service or Insurance Company.

Table 3. Appraisal of plants partially destroyed.

Period Required to Reach Pre-disaster Value	*% Loss*
10 or more years required for complete recovery	100
9 years required for complete recovery	90
8 years required for complete recovery	80
7 years required for complete recovery	70
6 years required for complete recovery	60
5 years required for complete recovery	50
4 years required for complete recovery	40
3 years required for complete recovery	30
2 years required for complete recovery	20
1 year required for complete recovery	10

Table 4. Sample form for reporting deductible losses.

DAMAGE TO HORTICULTURAL PLANTS

DURING HURRICANE BEULAH SEPT. 19-22, 1967

Name	Address	Home or Business
Mr. and Mrs. Harde H. Hittee	1721 Park Street Kingsville, Texas	Rental Duplex 113-115 So. 2nd

Name of Plant	*Ht. (ft.)*	*Spread Diam. (ft.)*	*Location**	*Pre-Storm Value*	*% Loss*	*Deductible Loss*
Acacia Farnesiana (Huisache)	20	24	+10%	$167.20	100	$167.20
Sapium Sebiferum (Chinese Tallow)	26	18	—	220.00	50	110.00
Sapium Sebiferum (Chinese Tallow)	24	20	+20%	264.00	30	79.20
Citrus Sinensis (Orange)	16	16	+10%	239.80	30	71.94
			Total Deductible Loss			$428.34

*Increased value of Plants serving special purposes

CONCLUSIONS AND RECOMMENDATIONS

The worth of ornamental plants in a landscape has become more widely recognized. Education, high standard of living and more leisure time have helped bring about this new value system. Expanded insurance coverage and more detailed reporting required by the Internal Revenue Service have increased the need for expert appraisal of plant values and losses.

The horticulturist with his experience in growing and maintaining ornamental plants is qualified to do appraisals and evaluations. It is a service he can and must render.

Times Publishing Co., Mission, Texas